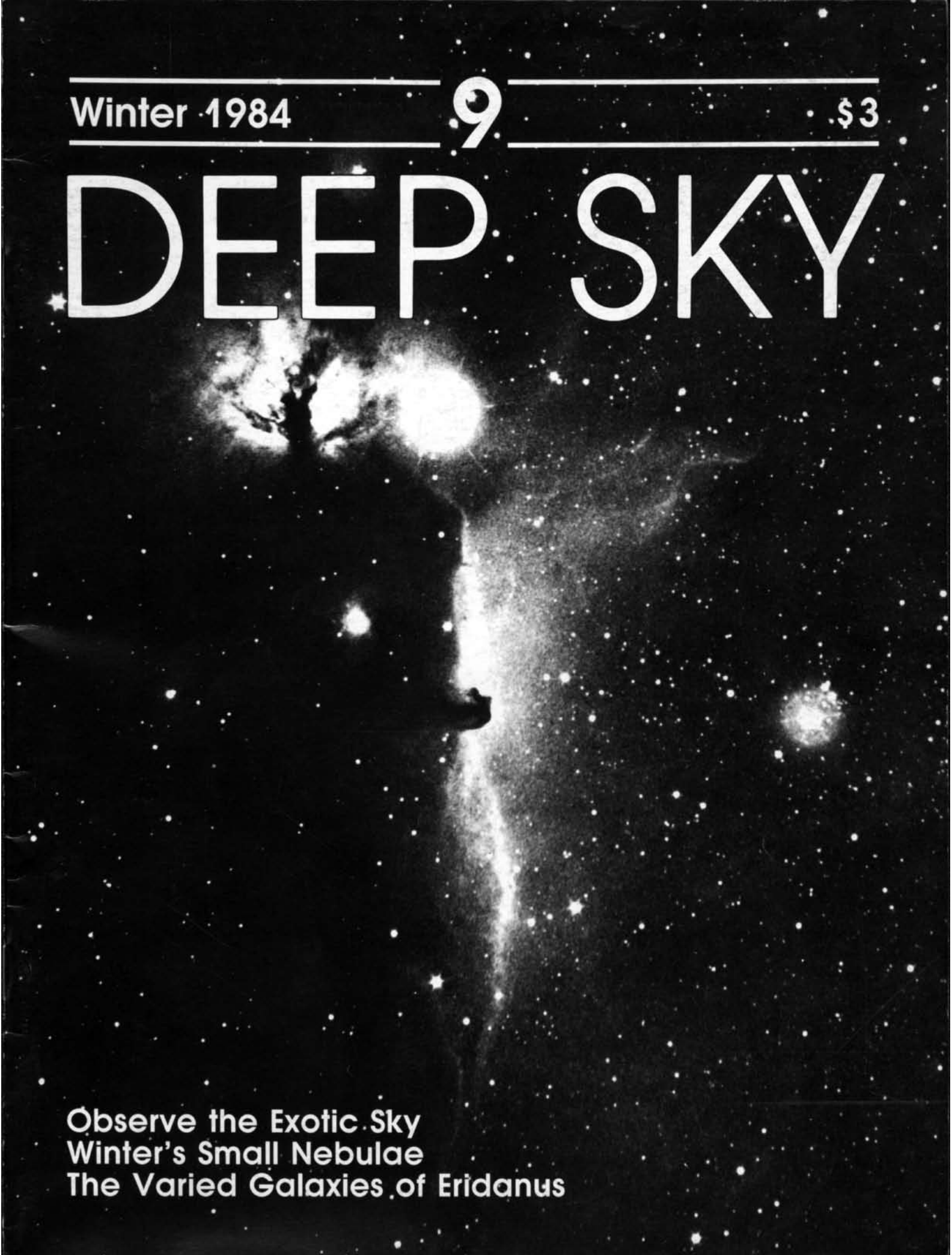
Winter 1984 9 $3

DEEP SKY



Observe the Exotic Sky
Winter's Small Nebulae
The Varied Galaxies of Eridanus

Letters to DSM

Jim Riffle

A Close Encounter

Dear Sir / During the final days of October, Jupiter passed a mere 35′ north of the globular cluster M22 in Sagittarius. Enclosed is a print showing the close approach made on October 28, 1984. To record both objects, I used a 12-inch f/5 Maksutov, 103a-F film, and a 3-minute exposure. Although the planet is greatly overexposed and haloed, one Galilean moon is visible between the disk and the halo.

Jim Riffle
175 Piedra Loop
Los Alamos, NM 87544

California, Here We Come!

Dear Dave / Mel Bartels' report of seeing the California Nebula (NGC 1499) with his 8-inch telescope, printed in *Deep Sky* 8, prompted me to tell you about my own experience. On the morning of September 26, 1984, I easily spotted the California Nebula using my 5-inch f/5 Jaegers refractor at 25x, and a Lumicon Hβ filter. I observed it from the Apple River Canyon State Park in northwestern Illinois. Slightly shifting the 2.5° field of view easily revealed the edges of the giant nebula.

On the same morning, using a friend's 16-inch reflector, I also saw for the first time the Horsehead Nebula in Orion.

John D. Phelps, Jr.
8621 West 167th Place
Orland Park, IL 60462

Maffei 1 Spotted!

Dear Mr. Eicher / In past years, I've noticed many observers gaining interest in locating extremely faint, low-surface-brightness objects. Many deep-sky objects which used to be considered difficult — such as the Veil Nebula, Leo I or the Sculptor dwarf galaxies, the Witch Head Nebula in Eridanus, NGC 2174/5 in Orion, and others — are observable under good conditions with big telescopes.

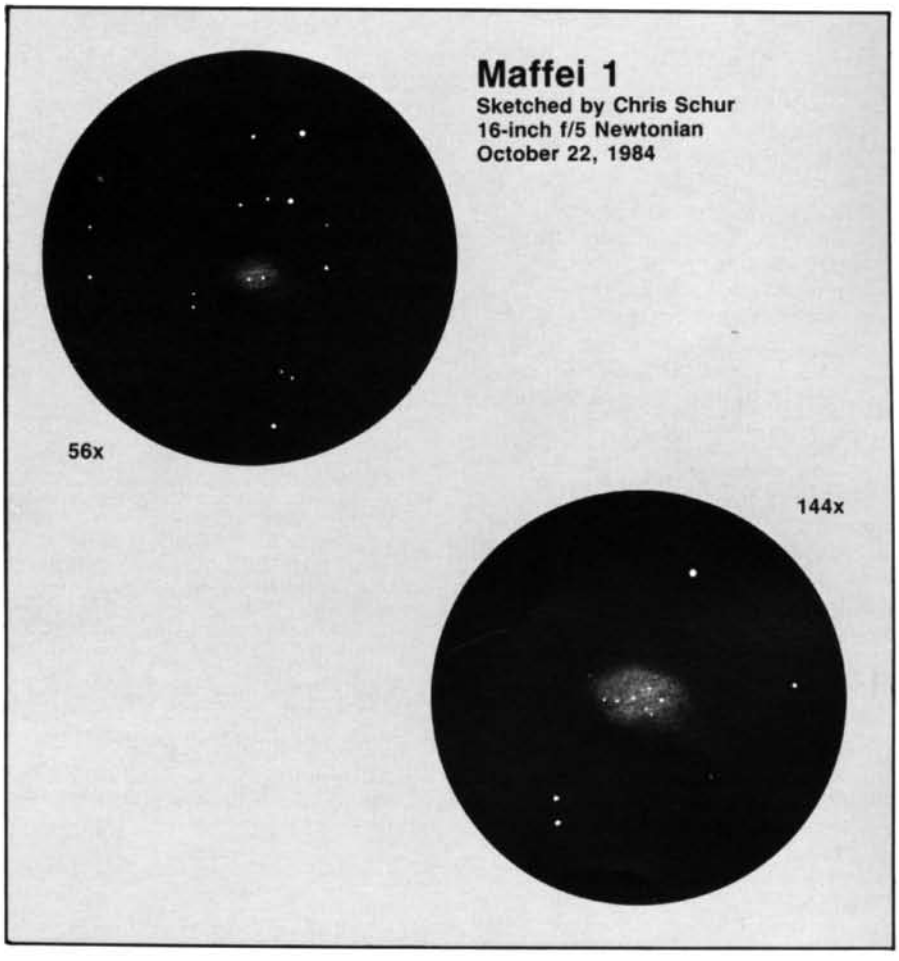
Some of these difficult objects really *are* difficult. Maffei 1, a nearby galaxy discovered by Paolo Maffei in 1968, lies in the heavily dust-laden constellation Cassiopeia and is so reddened by the Milky Way that its would-be brightness of 6th magnitude is reduced to 12. Its reported surface brightness is 19.6! Nevertheless, I decided to try to find it visually with my 16-inch Newtonian. For a finder chart, I used red prints from the Palomar *Sky Survey* made with a 1.2-meter Schmidt. Admittedly, a 2,000-foot elevation at my observing site and crystal-clear Arizona skies helped, but I spotted Maffei 1 without too much difficulty using my 32mm Erfle.

Enclosed are two drawings of the Maffei 1 field made at 56x and 144x. It reminded me of IC 5146, the Cocoon Nebula in Cygnus. To confuse things a bit, a group of half a dozen faint stars lies right on top of the galaxy — but the diffuse glow from Maffei 1 is much larger than the grouping of stars. I think that under perfect conditions a 12-inch or 14-inch scope would reveal Maffei 1 to a trained eye. But don't bother with Maffei 2, a fainter infrared galaxy also discovered in 1968, which lies nearby. I searched for some time and found nothing but blank sky at its position, although my 7-inch f/2.5 Aero-Ektar lens recorded both galaxies on red-sensitive color film.

Chris Schur
HCR Box 952
Black Canyon City, AZ 85324

Dear Chris / Thanks for letting me know about successfully finding Maffei 1 — I was beginning to wonder if anyone ever would! For positional information on the galaxy, see this issue's lead article. — D.J.E.

See Letters, page 4



DEEP SKY 9

The magazine for deep-sky observers and astrophotographers

Volume 2, Number 4
Winter 1984

Cover: Nebulosities surrounding the star Zeta (ζ) Orionis, photographed by Ron Potter; 8-inch f/1.5 Schmidt camera, hypered TP 2415 film + #92 red filter, 15-minute exposure.

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6 Twenty-One Exotic Deep-Sky Objects

by David J. Eicher

From our Earthly perspective, deep-sky objects generally appear faint and unchanging. But certain types of nebulae and galaxies are actually quite active, so much so that it would probably be dangerous to be near them. This exotic fare includes active galaxies, interacting pairs of galaxies, variable nebulae, strange stars, black holes, and supernovae remnants. The article examines 21 of the most prominent cases of exotic behavior in the universe, and explains how readers can go about observing them.

16 Observing Galaxies in Eridanus

by Jim Barclay, Steve Coe, A.J. Crayon, Christian Luginbuhl, and Brian Skiff

The constellation Eridanus the River is one of the largest in terms of sky area, yet it is not known for containing anything of interest. Lying slightly away from the plane of the Milky Way and southwest of brilliant Orion, to many observers it appears the River's current has washed away any former deep-sky treasures. But this article by a group of observers from Arizona and Australia tabulates information on 64 little-known galaxies found in Eridanus, many of which are quite attractive when observed under dark skies.

24 Observing Small Nebulae — Part 1

by Chris Schur

Those "little green boxes" on Becvar's Atlas of the Heavens *and Tirion's* Sky Atlas 2000.0 *mark the positions of often ignored small emission and reflection nebulae scattered along the galactic equator. In this first of a two-part article, Chris Schur details 46 small nebulae of the winter sky. (Part 2 will appear in Deep Sky 11.)*

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Gerald P. Dyck

Ichabod Rides Again

Dear Dave / Here is an item from my slideshow "Great Moments in Astronomy...Which Almost Everybody Missed." Many observers try to see the difficult Horsehead Nebula in Orion, and some even find it. But few realize that a fainter detail inside the nebulosity exists, and appears remarkably like Ichabod Crane, the frightened schoolmaster from Washington Irving's 1819 classic, *The Legend of Sleepy Hollow*. Maybe some sharp-eyed observers with 24-inch scopes will be able to pick this one out!

Gerald P. Dyck
418 High Hill
North Dartmouth, MA 02747

What's Your Toughest Galaxy?

Dear Sir / Regarding the letter in *Deep Sky* 7, requesting designations of the "toughest galaxies" for our telescopes, I feel well qualified to answer having just observed my 500th galaxy. I observe with a Celestron-8 at f/10, and use 28mm and 15mm eyepieces from relatively dark skies in southern Ontario (latitude: 44° North, faintest naked-eye star: magnitude 6 to 6.5). I've recorded a total of 16 galaxies which are at the limit of visibility, and often only with averted vision. They are: NGC 3319 and NGC 3687 in Ursa Major; NGC 4178, NGC 4795, NGC 5088, and NGC 5690 in Virgo; NGC 4236 and NGC 4319 in Draco; NGC 2798 and NGC 2844 in Lynx; NGC 3187 in Leo; NGC 7300, NGC 7309, and NGC 7723 in Aquarius; and NGC 7320 and NGC 7741 in Pegasus.

I enjoyed the "Low Surface Brightness Objects" articles. With the 8-inch scope I've been able to find some faint ones, including the Horsehead Nebula in Orion, the Veil and North America Nebulae in Cygnus, the Helical Nebula in Aquarius, the Bubble Nebula in Cassiopeia, and the faint emission nebula IC 1396 in Cepheus.

Keep up the good work.

Chris Malicki, M.D.
1131 Pomona Court
Mississauga, Ont. L5C 1N3
CANADA

Dear Dave / In *Deep Sky* 7, Brian Skiff asked for data on the faintest galaxies readers could see with their scopes. I do not know if I have seen the absolute faintest with mine, but there is a good chance I have. On both evenings I tried to determine the limit, I was using a 10-inch Dobsonian and a 9mm Nagler eyepiece, yielding 125x.

On September 19th, 1984, when viewing Stephan's Quintet in Pegasus, I could hold NGCs 7320, 7319, 7318A, and 7318B with direct vision. Fading in and out of sight, to my surprise, was NGC 7317.

On September 29th, I decided to try viewing the Pegasus I Galaxy Cluster which was described by Jim Meketa in *Deep Sky* 4. Indeed Jim was right about the cluster looking like a smaller version of the center of the Virgo Cluster. I saw many faint galaxies scanning around the immediate area, and eventually counted 19, most with difficulty. I positively identified 10, using Mr. Meketa's chart: NGCs 7608, 7611, 7612, 7615, 7617, 7619, 7621, 7623, 7626, and IC 5309.

This puts the faintest galaxy at a surface brightness of about 15 magnitudes per square arcminutes. I would be interested in hearing others' reports of observing the Pegasus I Cluster of Galaxies.

Jay Moynihan
Box 253
Ashland, WI 54806

Population What?

Dear Dave / In Jim Meketa's article "The Ophiuchus Globulars," which appeared in *Deep Sky* 7, Mr. Meketa incorrectly stated that the Sun is a Population II star. It is actually a Population I star, one which formed in the disk of the Galaxy and not out in the halo.

John H. Hanson
6 North Stuart Street
Westerly, RI 02891

Dear Mr. Hanson / You are quite correct: there are five basic separations of Population I and II type objects which inhabit the Galaxy, whose memberships are as follows: ***Extreme Population I:*** *interstellar gas and dust, HII regions, T Tauri stars, O associations, O and B stars, supergiants, young open clusters, and classical Cepheids.* ***Older Population I:*** *The Sun, strong-line stars, A stars, Me dwarfs, giants, older open clusters.* ***Disk Population:*** *weak-line stars, planetary nebulae, galactic bulge, novae, short-period RR Lyrae stars.* ***Intermediate Population II:*** *high-velocity stars, long-period variables.* ***Halo Population II:*** *globular clusters, extreme metal-poor stars, long-period RR Lyrae stars, Type II Cepheids.*

The Sun fits in as an old Pop I object, and was mistakenly mentioned as a Pop II object in the article. — D.J.E.

Bart Bok Memorial Fund

Dear Dave / The Astronomical Society of the Pacific has established a fund to carry on the work of astronomer Bart J. Bok. Seed grants totaling $23,000 have already been received from the Perkin Fund, and from several of Bart Bok's students and colleagues. The ultimate goal is to raise $100,000 to support a variety of programs in public education.

These programs will include a Bart J. Bok memorial Lecture Series, in which eminent research scientists would give nontechnical talks to large public audiences; workshops on astronomy for schoolteachers in grades K-12; the development of authoritative, informative materials on astronomy for use in schools, libraries, and youth groups; and support for the Bart and Priscilla Bok awards for high school astronomy projects.

All gifts to the fund are tax deductible; acknowledgments will be sent to both the donor and to Bart Bok's children. Checks should be made payable to "A.S.P./Bart Bok Fund" and sent to the society's offices at: 1290 24th Avenue, San Francisco, CA 94122.

Andrew Fraknoi,
Executive Officer
Astronomical Society of the Pacific
1290 24th Avenue
San Francisco, CA 94122

MIRA's Wonderful 36-inch Scope

While attending the ALCON '84 convention near Milwaukee this summer, I met Bill Kaufmann, the well-known lecturer and author of astronomy textbooks. He mentioned that a new 36-inch f/10 telescope was "up and running" in the Los Padres National Forest in California. The telescope is operated by the Monterey Institute for Research in Astronomy (MIRA), a group of astronomy graduates from Case Western Reserve University in Cleveland.

I promptly donated a selection of accessories for this telescope, naturally offering to deliver them in person. On Friday, August 31st, my family and I — accompanied by friend and expert observer Bill Faatz — left for MIRA. We arrived on Chews Ridge, some 5000′ above sea level, just before sunset and set up camp. The observatory is some 30 miles inland, but we glimpsed the setting Sun on the Pacific Ocean — a lovely sight! Luckily, Friday and Saturday night were set aside for visual observing, so astronomers Bruce Weaver and Cynthia Irvine began by showing the group of about 20 people the planets.

After some time passed, the newcomers left and we trained the telescope on deep-sky stuff. A real showpiece that evening was the great globular cluster M13, which filled the field of a 2-inch diameter 32mm Erfle. At 285x, M13 appeared bright and was resolved into thousands of stars. This was fine, but we wanted to look at fainter objects — this *was* a 36-inch telescope, after all! NGC 6826, the Blinking Planetary in Cygnus, was impressive — but it didn't blink. The 9th magnitude disk held steady all the time and was strongly blue-green in color. The 11th magnitude central star punched through brilliantly!

Next, we tried Stephan's Quintet in Pegasus, a small group of five galaxies half a degree southwest of the 10th magnitude spiral NGC 7331. I remembered my first view of Stephan's Quintet many years ago: an amateur invited me to look at it with an 18-inch telescope from Digger Pines, California, and as I peered in the eyepiece I expected an impressive view. I couldn't see anything! Since then, I've observed it many times, fully appreciating its difficulty. In the 36-inch MIRA telescope, however, it really *was* impressive; all five components very easy to see. Sharp-eyed Bill Faatz said he could also see a 6th galaxy in the field. I looked in and, with averted vision, quickly discovered he was right. When we got back, I looked it up and learned it was 17th magnitude NGC 7320c. We will never forget our view of Stephan's *Sextet* that night.

On Saturday night we started by looking at the Ring Nebula. I asked several people if they could see color in M57. I could not, but several observers said it appeared blue-green, the correct visual color. At 285x, the central star was visible to experienced observers and occasionally by the guests. Then I put in a 19mm eyepiece, yielding 480x. Because of superb seeing that night, the image stayed crisp and the Ring's central star was visible *continuously*, even without averted vision. Several observers thought they could see a second star inside the Ring and a third star embedded inside the nebulosity. These stars show up in photos of M57, but I could not see them.

Even though the Moon eventually came up, we went on to the Veil Nebula. The eastern half, NGC 6992-5, was striking in its sheer size. We used a UHC filter to suppress the moonlight,and this brought out the turbulent mix of loops, swirls, and glowing bands. Alas, the astronomers operating MIRA shut down at 11pm, just half an hour before moonset. Appreciating the visual sky was not so important to the astronomers as we had hoped! The MIRA telescope has superb optics and is located at a very dark site. Its computer controls still have bugs, but the astronomers there have an exciting future ahead of them. They have earned it.

Jack B. Marling
Lumicon, Inc.
2111 Research Drive, #5
Livermore, CA 94550

Inside View

The Exotic Sky

Most of us enjoy astronomical observing because, among other things, it is a peaceful and relaxing experience. But if we were closer to certain "faint fuzzy patches," they would transform into violent exotic worlds where large-scale devastation and danger were the norm. Seyfert galaxies, quasars, black holes, N-galaxies, Markarian galaxies, interacting galaxies, thick clouds of cosmic dust, BL Lacertae objects — all are woven together by the common thread of unpredictability.

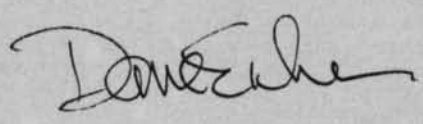
Affixed here on Earth and armed only with backyard sky-gazing gear, we cannot witness much of the exotic universe. But knowing that certain objects display exotic characteristics tells us *yes*, that 10th magnitude galaxy is a Seyfert experiencing a powerful and irregular variability within its nucleus. Or that innocent-looking double star only 2.5 kiloparsecs away from the solar system is actually hiding a black hole.

This issue's lead article tells the story of 21 exotic objects, which go largely unnoticed by amateurs. They range from moderately well-known but difficult objects (the Horsehead Nebula, Stephan's Quintet) to what appear at first glance as anonymous and unimportant NGC entries (distorted galaxy NGC 520, nearby globular cluster NGC 1049).

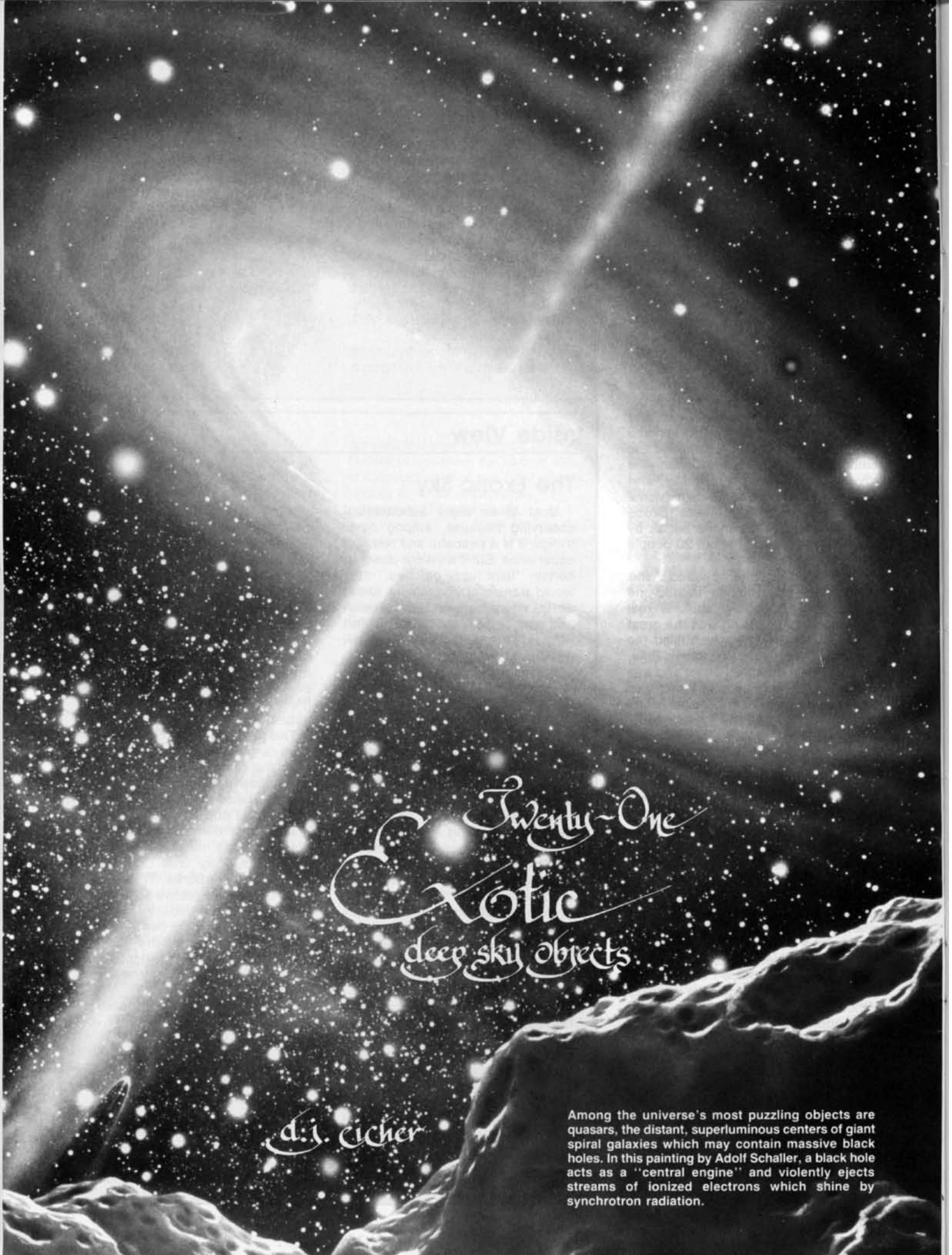
Our following two stories feature galaxies and small nebulae. Inspired by correspondence with Australian observer Jim Barclay, Steve Coe of Phoenix gathered together a group of observers and approached me with the idea of writing a series of constellation articles. Their first, on Eridanus the River, includes tabulated data and descriptions for over 70 galaxies. Chris Schur, also from Arizona, has complied a descriptive catalogue of the winter's best small nebulae — objects that often go unobserved because they appear as miniscule "green boxes" on Wil Tirion's *Sky Atlas 2000.0*. (Part 2, "Summer's Nebulae," will appear in *Deep Sky 10*.)

This month in "DSM Reports," our wide-ranging forum department, we offer two special articles. The first sheds new light on the discussion over published magnitudes for deep-sky objects and how seriously you should take them. It incorporates comet-hunting techniques and is written by *Sky and Telescope* columnist John Bortle. The second report, a serio-detective story about a flare star in Cassiopeia, is by Paul Roques. Its historical bent explains what happened at the Griffith Observatory in Los Angeles on October 9, 1961 — a story nearly as old as your editor.

Best wishes,



Dave Eicher
Editor



Among the universe's most puzzling objects are quasars, the distant, superluminous centers of giant spiral galaxies which may contain massive black holes. In this painting by Adolf Schaller, a black hole acts as a "central engine" and violently ejects streams of ionized electrons which shine by synchrotron radiation.

Remember the last time you were out under the stars? You looked up at the quiet points of light in the sky and they relaxed you — they seemed so simple, so attractive, so peaceful. But we can afford that illusion only because of the great distances between our Galaxy and others; were you close to some of those tiny peaceful points, you would gain a much different perception of them! Quite often, the universe is a terribly violent and complex place. Most of the large-scale chaos happens in external galaxies rather than in the Milky Way: galaxies stricken with cosmic flu flicker in light output; jets of ionized gas stream outward from galactic nuclei; galaxies collide and disrupt star-forming regions; and gravity gathers together dust particles and compresses them into infant stars.

Large-scale activity is indeed present in the cosmos around us, but don't expect to see purple flashing lights. The "action" is not directly visible with backyard telescopes — we need the help of science to realize what is taking place. But you can go out on any clear night and see faint lights representing the sites of many of these astronomical oddities. If you've never looked at a strange object in our Galaxy or beyond, why not begin your odyssey among the exotic sky sights tonight?

One of the brightest of the sky's more unusual galaxies is **NGC 5128** in Centaurus, a stellar system rich in gas and dust, and composed of a circular disk and halo with a dark absorption zone. Probably 30 kiloparsecs across, this object contains over 200 billion solar masses, is classed as either an elliptical or a lenticular (lens-shaped) galaxy, and is listed as object 153 in Halton Arp's *Atlas of Peculiar Galaxies*. In 1949, astronomers discovered that this object corresponds to a high-intensity radio source called Centaurus A, which emits over 1000 times as much radio frequency radiation as the Milky Way — much of it from the object's dark band of dust. This radio energy extends outward from the galaxy in two symmetrical lobes, indicating an intense magnetic field. In the 1950s, Walter Baade and Rudolph Minkowski explained this occurrence as two colliding galaxies, but more recent observations have scuttled their idea. NGC 5128 is most likely a single galaxy experiencing massive explosions in its center, involving millions of stars and perhaps even a supermassive black hole. Nowadays, astronomers call these energetic systems "active galactic nuclei."

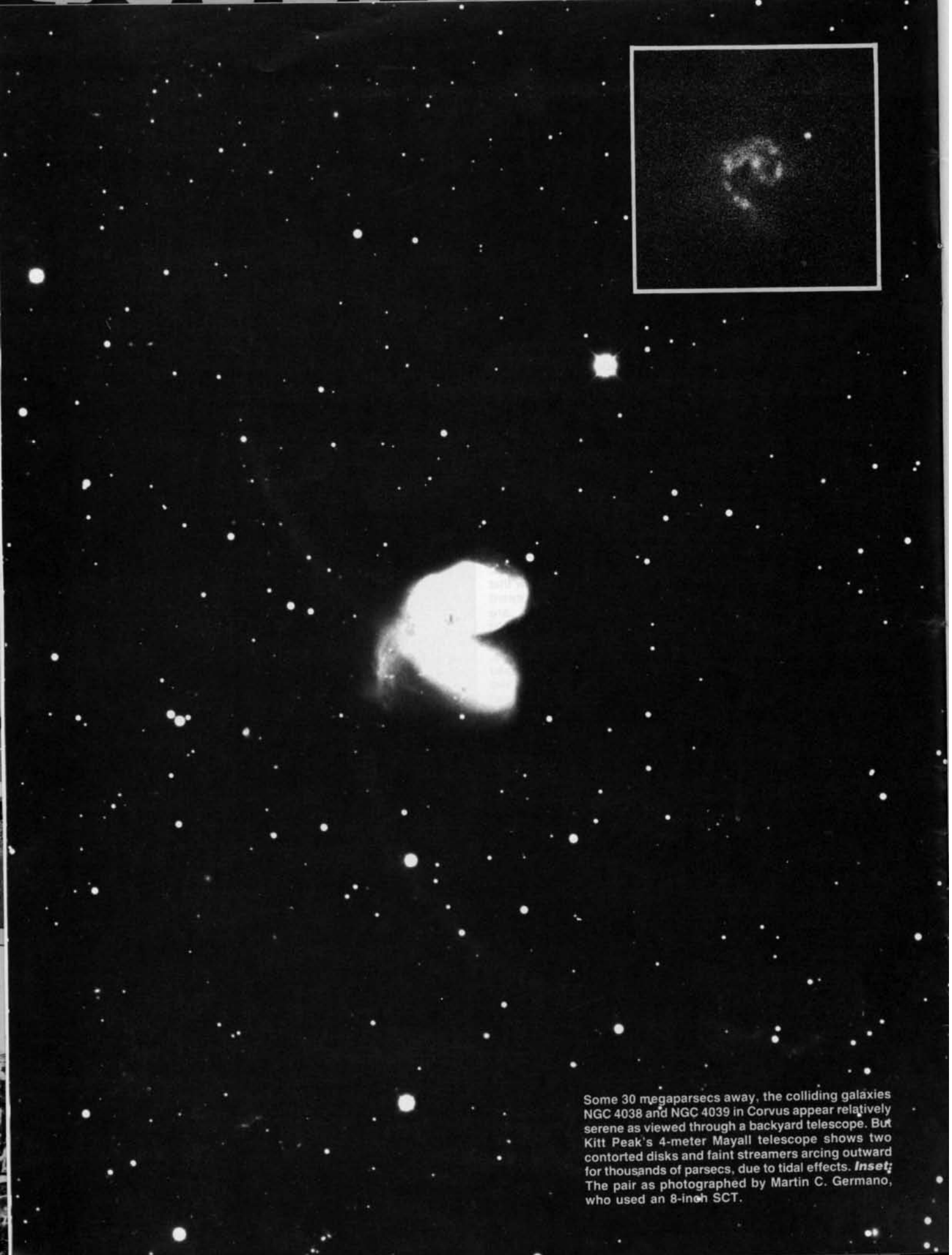
At magnitude 7.2, NGC 5128 is easily visible in even small telescopes as a round haze, but it lies at a southerly declination — just 4.5° north of globular cluster Omega (ω) Centauri — which prohibits many North Americans from viewing it. On dark nights, a 4-inch scope shows the prominent dark band that crosses the nuclear region and an 8-inch reveals a subtle gradation of greenish-white light over its face. An 18-incher reveals misty light inside the 1′ wide dark band and a faint outer halo extending at least 15′ in diameter. The nebulosity inside the dark obscuring matter represents light from chains of hot O- and B-type stars, most of which shine at about 18th magnitude. The 18-incher also shows many tiny field stars suspended in space in front of this great ball of suns.

Another possible exploding galaxy is **NGC 1275** in Perseus, also known as 3C 84. Like NGC 5128, NGC 1275 is an intense radio energy emitter, and is also known as Perseus A. This object is the brightest member of a small cluster of galaxies near Algol (Beta [β] Persei), and is catalogued variously as an elliptical, lenticular, or tight spiral. It is extremely rich in gas and dust clouds — hundreds line its edges — some of which differ in redshift by as much as 2900 kilometers per second from the galaxy's core. Red-light photographs show that filaments of gas extend outward from the galaxy; these are calculated to be moving at 245,000 kilometers per hour. Just as for NGC 5128 and also in the 1950s, Baade and Minkowski proposed that NGC 1275 was in fact two colliding galaxies. They based their hypothesis on the fact that colliding gas clouds would produce very high temperatures and strong radio emission. But again their model fails: the galaxy emits far too much energy to be explained by hot gas clouds. In the 1970s, astronomers found that NGC 1275 also emits large amounts of X-rays. This, coupled with the existence of outward-shooting gas, now leads to the conclusion that NGC 1275 — like Centaurus A — is experiencing a massive explosion within its nucleus, perhaps involving a black hole.

In a telescope, NGC 1275 is a small object less than one arcminute across and fairly dim at 13th magnitude. You'll need a 6-inch scope to detect it as a small fuzzy patch, and twice that aperture to see a roundish, fuzzy patch of light slightly condensed in the center. A really big telescope like an 18-incher doesn't show much more of this distant galaxy, as the expanding tendrils of gas are impossibly faint to observe visually.

One of the largest members of the Virgo Cluster, **M87** (NGC 4486) is a giant elliptical galaxy that is home for nearly a billion solar

Above: **The galaxy NGC 4319 (center) and quasar Markarian 205 (below center) lie along the same line of sight and, according to a few astronomers, may be physically associated even through their redshifts indicate radically differing distances. Jack W. Sulentic made this photo using the 5-meter Hale telescope at Palomar Observatory; the image was digitally processed at the Jet Propulsion Lab.** ***Left:*** **The pair as photographed with a common 8-inch SCT. Photo by Martin C. Germano.**



Some 30 megaparsecs away, the colliding galaxies NGC 4038 and NGC 4039 in Corvus appear relatively serene as viewed through a backyard telescope. But Kitt Peak's 4-meter Mayall telescope shows two contorted disks and faint streamers arcing outward for thousands of parsecs, due to tidal effects. ***Inset:*** The pair as photographed by Martin C. Germano, who used an 8-inch SCT.

masses of material. The galaxy also bears the designations 3C 274 and Virgo A, in reference to its strong radio emission, first detected in 1948. This object is the fifth most intense radio object in the entire sky and, in the 1960s, was found to be an X-ray source; its energy appears to radiate from a curious, optically-visible "jet" of material shooting out of the core. The jet — first noticed by astronomer Heber Curtis in 1918 — is about 1.3 kiloparsecs long and contains six distinct "knots" of material. It is undoubtedly displaying synchrotron radiation: high-speed electrons spiraling through an intense magnetic field and emitting light as a by-product. Again we can tentatively conclude that, at some point, M87 underwent a massive outburst in its core.

At 10th magnitude and 3′ across, this galaxy is much easier to observe than NGC 1275, but it still appears as a fuzzy round ball in most telescopes. A 3-inch instrument shows it as a fuzzy "star," whereas a 6-incher at high power shows a round disk of bright nebulosity with an intense core. The view doesn't improve dramatically in larger telescopes and the jet of gaseous material is much too faint to detect.

NGC 1097, a galaxy 12 megaparsecs away in the constellation Fornax, is yet another so-called active galactic nucleus that appears to be violently throwing off material. This object is a relatively normal barred spiral with a tight nucleus, a dusty bar, and faint sharply-arcing spiral arms. It appears to be relatively calm, but when photographed with large telescopes and special filters it exhibits two very faint symmetrical rays of material extending out from the nucleus. Curiously, one of the rays is blueshifted and the other redshifted; this may indicate an explosive origin. The rays are at least 70 kiloparsecs long and, once again, are probably composed of high-speed electrons. Could NGC 1097, too, be the site of a supermassive black hole?

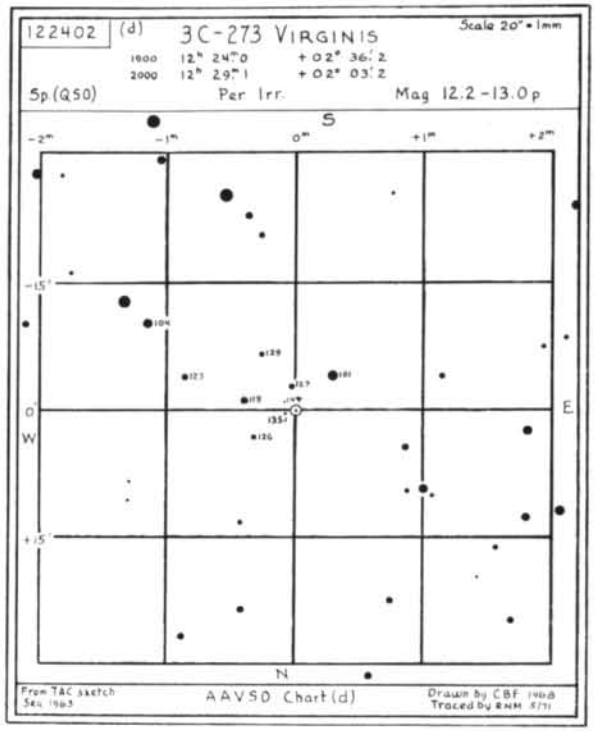
Fairly large but of low surface brightness, NGC 1097 is a 10th magnitude galaxy that looks good at low power. A 6-inch telescope shows a bright, condensed, elongated nucleus with a larger misty haze superimposed on top of it. A 12-incher reveals little more, but hints at some dark structure around the bar and also a stellar nucleus. Still larger telescopes show traces of the low-luminosity spiral arms, but they are not defined very well. The luminous synchrotron radiation is much too faint to see in telescopes.

Maffei 1 is an infrared object discovered by Italian astronomer Paolo Maffei in 1968. It appeared as a faint smudge of light on long-exposure photographs of a region near the plane of the Milky Way in Cassiopeia; three years later, a team of researchers discovered that it is a galaxy heavily obscured by our Galaxy's gas and dust. It lies only 1.0 megaparsec away, and is probably a member of our Local Group of galaxies: if so, it is one of the largest members since it holds 200 billion solar masses of material. If Maffei 1 were away from the Milky Way, it would glow about one hundred times brighter and be a spectacular sight in our skies. But this hidden giant measures only 50 arcseconds across and dimly glows at 11th magnitude — unfortunately, it is so heavily obscured that its peak surface brightness is 19.6 magnitudes per square arcminute. It is beyond the reach of amateur instruments for visual observing, but can be photographed with a 60-minute exposure using an 8-inch f/10 SCT.

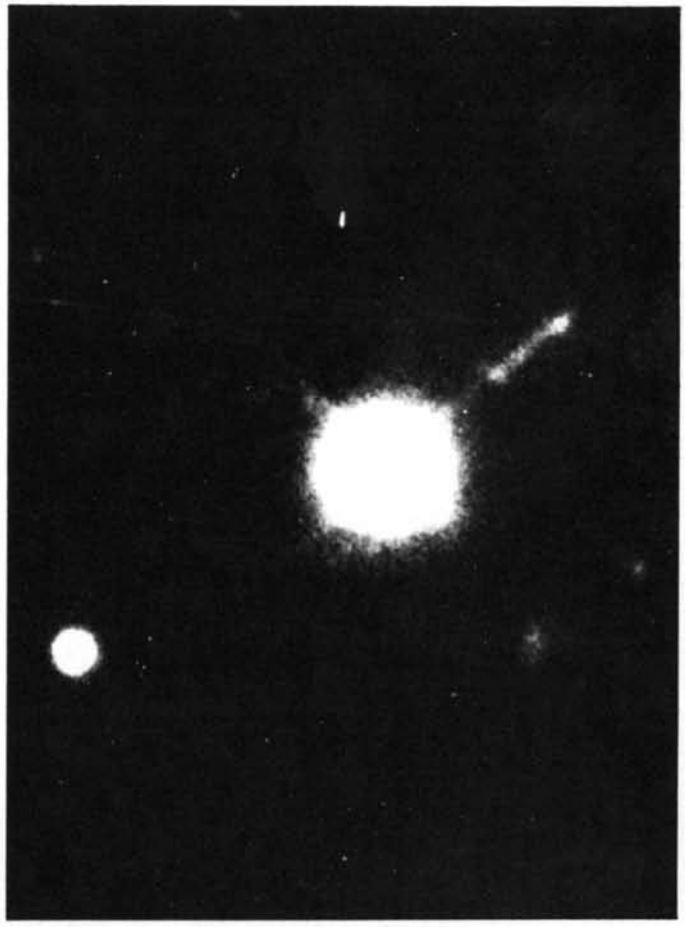
NGC 4038 and **NGC 4039**, two faint galaxies 30 megaparsecs away, together compose a single object called the "Ring-Tail Galaxy"; it is also catalogued as Arp 244 because of its odd, twisted shape. Located in the sky about 4° west-southwest of Gamma (γ) Corvi, these actually *are* colliding galaxies! On long-exposure plates, the object shows lengthy, sweeping filaments of gas arcing away from the main body; this probably represents a tidal or magnetic pull caused by the collision. When galaxies collide, there really isn't much danger of individual stars colliding due to the great distances between them. Most stars travel through such encounters relatively unchanged, save for a gravitational tug on their galactic orbits. The chaotic fireworks occur when gas and dust clouds in galaxies collide; they are large and dense enough to slam into each other pretty much "head on," giving rise to large-scale destruction and radio emission — a classic display of heat and light.

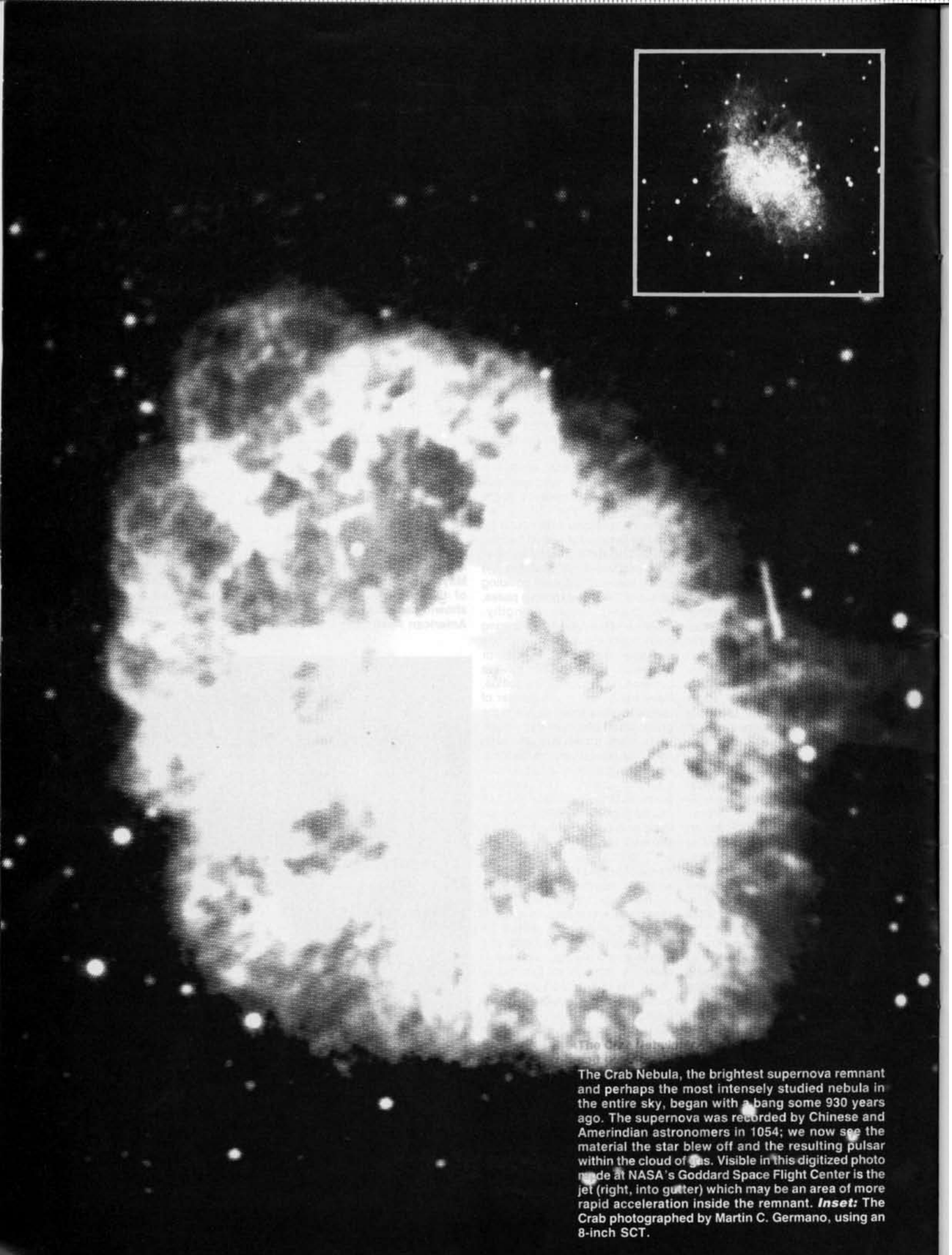
The Ring-Tail shines at 11th magnitude and measures about 3′ across; it is an easy target for 6-inch and larger telescopes, and appears as a warped, backwards question mark in an 8-incher at 100x. The object has a pretty high surface brightness and withstands high magnification. A 16-inch telescope shows an uneven texture in the nebulosity and a star just off the northern edge. Using averted vision and slowly sweeping the telescope's field of view back and forth will help in observing this faint but detailed galaxy.

Stephan's Quintet in the constellation Pegasus is a group of interacting galaxies made up of four physically associated objects — NGC 7317, NGC 7318, NGC



Below: **The quasar 3C 273 in Virgo, photographed with the 4-meter Mayall telescope. Note the faint jet of material to the upper right of the quasar.** ***Above:*** **A telescopic finder chart for 3C 273, showing south at top and west at left. Used by permission of the American Association of Variable Star Observers.**





The Crab Nebula, the brightest supernova remnant and perhaps the most intensely studied nebula in the entire sky, began with a bang some 930 years ago. The supernova was recorded by Chinese and Amerindian astronomers in 1054; we now see the material the star blew off and the resulting pulsar within the cloud of gas. Visible in this digitized photo made at NASA's Goddard Space Flight Center is the jet (right, into gutter) which may be an area of more rapid acceleration inside the remnant. ***Inset:*** The Crab photographed by Martin C. Germano, using an 8-inch SCT.

7318A, and NGC 7319 — and a fifth — NGC 7320 — that happens to lie along the same line of sight. Astronomers are divided with regard to the galaxies' fates: some believe that the four are collapsing in upon each other; others think the group is expanding and flying apart. In 1959, Geoffrey and Margaret Burbidge studied the galaxies and concluded they must be expanding away from each other. At a distance of 80 megaparsecs, they are all 14th and 15th magnitude objects — but a 12-inch telescope shows each of them as tiny faint patches of light.

Another strange galaxy is **NGC 2685** in Ursa Major. Also known as Arp 336, this unusual object is composed of a relatively normal lenticular body which radiates at 12th magnitude with a faint outer ring wrapping it at right angles (picture a cigar with a loose ring perpendicular to its midpoint). Astronomers don't yet know why this ring exists or how it got to be there, but one possible explanation is that NGC 2685 is an old system of colliding galaxies. It is a nice object in backyard telescopes, appearing as a small spindle of faint hazy light. A 16-inch scope shows it to be bright and slightly bulged in the middle, but the encircling rings of gas are impossibly faint to view in amateur instruments.

NGC 520 (Arp 157) is a galaxy in Pisces that shows structural peculiarities similar to NGC 2685. It shows a twisted dusty merger of two apparent objects and faint streamers extending outward from the core. This object is either two colliding galaxies or one with a highly-disturbed nuclear region. It is a fairly large, magnitude 11.5 object and thus has a pretty low surface brightness; it looks like a ghostly sliver in an 8-inch instrument. A 16-incher reveals that one end is considerably wider while the other dwindles to a point.

Seyfert galaxies are those with small bright nuclei whose spectra show strong emission lines. One of the brightest is **Messier 77** (NGC 1068), a magnitude 8.8 three-armed spiral in the constellation Cetus. M77 is the primary member of a group of galaxies which includes NGC 1055, NGC 1073, NGC 1087, and NGC 1090. It is historically notable because Vesto Melvin Slipher, working at Lowell Observatory in 1913, made spectra of M77 and M104, which were the first to detect extremely large redshifts. This was the basis for a great (and expanding) distance scale for the universe. M77 lies at a distance of 11 megaparsecs, making it one of the closest known Seyfert galaxies.

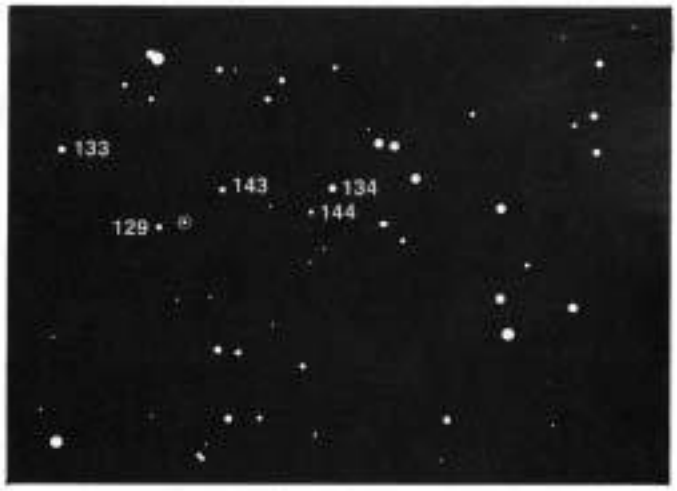
In a backyard telescope, M77 appears as a bright, well-defined galaxy, which easily shows a bright condensation of light about the nucleus. The spiral arms are much fainter, though visible as a uniform envelope of nebulosity measuring some 6.9′ x 5.7′ in extent. At high power under good seeing, a tiny condensed knot shows up which represents M77's flickering core.

There has been a lot of discussion among professional astronomers during the last several years about the galaxy/quasar "pair" **NGC 4319** and **Markarian 205** in Draco. In the early 1970s, when astronomer Halton Arp of Mount Wilson began his investigation of these objects, this duo became one of the strongest candidates for galaxy/quasar interaction. The two objects appeared to be connected by some sort of luminous bridge, yet their redshifts indicated vastly different distances from Earth.

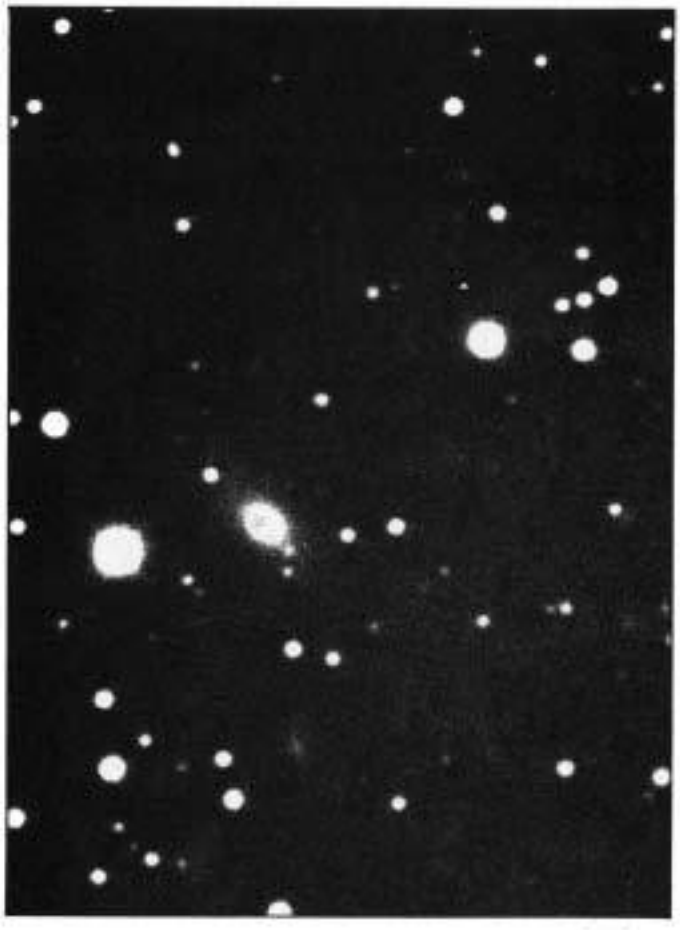
This past summer, however, work by Gerald Cecil and Alan Stockton of the University of Hawaii showed that the bridge is real, but does not form a connection between the galaxy and the quasar. Apparently there is a more distant, compact galaxy near Markarian 205 with which it is interacting. If this is proven, NGC 4319 lies 24 megaparsecs distant, while Markarian 205 is 12 times farther away — just as the differing redshifts indicate.

Even if the two objects are not associated, why not take a look at this "classic case." You won't see the bridge, but it's fun to track down and observe this controversial quasar. NGC 4319 shines at magnitude 13 and measures 3.1′ x 2.5′, so that it is easily visible as a small, elongated galaxy in a 6-inch telescope. The quasar is very nearly stellar and appears like a 16th magnitude "star" — you'll need at least a 12-inch telescope to spot it. A 17.5-inch reflector at low power shows both the galaxy and quasar well, revealing a hint of mottling in the galaxy's smooth arms.

But the sky's most renowned quasar is **3C 273** in Virgo, the first and brightest such object ever found. The designation 3C refers to the *Third Cambridge Catalogue of Radio Sources,* published in 1959. The 471 objects in the 3C catalogue were mostly nebulae and supernova remnants in the Milky Way, but astronomers soon suspected that some did not belong to our Galaxy. In 1960, they found that the source 3C 273, along with 3C 48 in Triangulum, corresponded to what appeared to be a star. But spectrographs showed a unique pattern of lines — one that didn't match *anything.* In 1963, Caltech astronomer Maarten Schmidt found the spectral lines made sense if they were shifted toward the red end of the spectrum by 16 percent. Thus quasars — quasi-stellar radio sources — were extremely distant



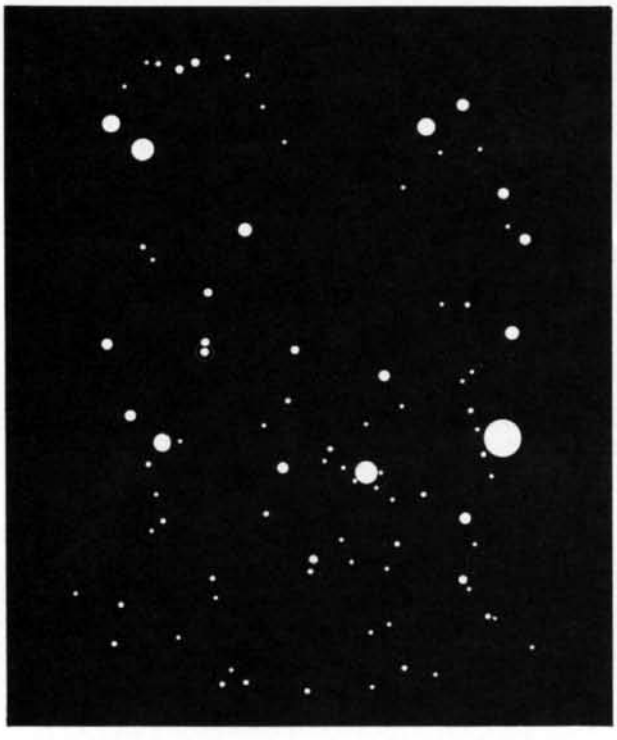
Below: **Related to quasars and active galaxies, BL Lacertae is a strange variable emission object some 380 megaparsecs distant in the constellation Lacerta. Once mistaken for a white dwarf, its rapid variations in light output suggest that in many ways it resembles a quasar. Photograph taken with the 4-meter Mayall telescope.** ***Above:*** **A finder chart for BL Lacertae (circled), showing V magnitudes with decimals omitted for field stars. North is up, east at right.**

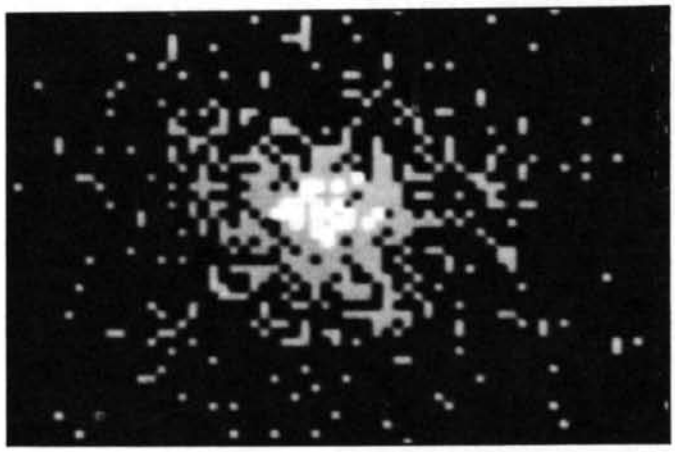


21 Exotic Deep-Sky Objects

Type	Designation	R.A. (2000) Dec.	Mag.	SB	Angular Size	Linear Diameter	Distance	Con
i§	NGC 520	1h24.6m +03°18′	11.2	14.4	4.8′x2.1′	20 kpc	16 Mpc	Psc
§L	Maffei 1	2h36.3m +59°39′	11.4	19.6	14.6′	10 kpc	2.1 Mpc	Cas
●	NGC 1049	2h39.8m −34°16′	12.6	—	50″	40 pc	150 kpc	For
S§	M77 (NGC 1068)	2h42.7m −00°01′	8.8	9.2	6.9′x5.7′	30 kpc	11 Mpc	Cet
AGN	NGC 1097	2h46.4m −30°17′	9.3	14.6	9.3′x7.9′	40 kpc	16 Mpc	For
AGN	NGC 1275	3h19.7m +41°31′	11.6	14.0	2.6′x1.3′	1 Mpc	100 Mpc	Per
v□R	NGC 1555	4h21.9m +19°32′	—	14	30″	0.02 pc	140 pc	Tau
SNR	M1 (NGC 1952)	5h34.5m +22°01′	7.5	13	8′x6′	2 pc	1.4 kpc	Tau
□D	Barnard 33	5h41.2m −02°31′	—	—	5.5′	0.3 pc	500 pc	Ori
v□R	NGC 2261	6h39.1m +08°43′	9	13	2′	0.2 pc	800 pc	Mon
AGN	NGC 2685	8h56.1m +58°47′	11.1	14.8	5.2′x3.5′	20 kpc	12.8 Mpc	UMa
i§	NGC 4038	12h03.1m −18°59′	10.7	12.8	2.6′x1.1′	15 kpc	19 Mpc	Crv
	NGC 4039		—	—	3.2′x1.8′	17 kpc	19 Mpc	
AGN?	NGC 4319	12h21.8m +75°19′	13.0	—	3.1′x2.5′	22 kpc	24 Mpc	Dra
QSO	3C 273	12h29.1m +02°02′	12.7	—	5″	2 kpc	1000 Mpc	Vir
AGN	M87 (NGC 4486)	12h30.8m +12°23′	8.6	13.8	7.2′x6.2′	24 kpc	11.5 Mpc	Vir
AGN	NGC 5128	13h25.3m −43°01′	7.0	13.9	18.2′x16.9′	30 kpc	4.0 Mpc	Cen
?	SS 433	19h11.7m +04°59′	13.7↔14.7	—	stellar	—	5 kpc	Aql
BH	Cygnus X-1	19h58.4m +35°12′	—	—	—	—	2.5 kpc	Cyg
SNR	NGC 6888	20h12.5m +38°25′	11	14	20.0′x10.0′	—	—	Cyg
BL Lac	BL Lacertae	22h03.1m +42°17′	12.5↔16.5	—	stellar	—	380 Mpc	Lac
i§	Stephen's Quintet	22h37.1m +33°56′	—	13.5	—	—	—	Peg
	NGC 7317		13.6	13.3	1.0′x0.8′	27 kpc	93 Mpc	
	NGC 7318A		13.3	13.2	1.0′x1.0′	27 kpc	93 Mpc	
	NGC 7318B		13.1	13.8	1.9′x1.3′	51 kpc	93 Mpc	
	NGC 7319		13.1	13.9	1.7′x1.3′	46 kpc	93 Mpc	
	NGC 7320		12.7	13.5	2.2′x2.2′	9 kpc	14 Mpc	

Column 1: type of object — ● = globular cluster in Fornax system; v□R = variable reflection nebula; □D = dark nebula; SNR = supernova remnant; §L = lenticular galaxy; S§ = Seyfert galaxy; i§ = interacting galaxies; AGN = active galactic nucleus; BL Lac = BL Lacertae object; QSO = quasi-stellar object; BH = possible black hole site. **Column 2:** name in *Revised New General Catalogue*, by J. Sulentic and W. Tifft, and additional lists; **Column 3:** coordinates for epoch 2000.0; **Column 4:** integrated magnitude in V system; **Column 5:** mean surface brightness in magnitudes per square arcminute; **Column 6:** angular size in arcminutes or arcseconds; **Column 7:** linear diameter in parsecs, kiloparsecs, or megaparsecs; **Column 8:** distance in parsecs, kiloparsecs, or megaparsecs; **Column 9:** constellation in which object lies. Data for globular star cluster from R. Racine and W. Harris, *ApJ* **196:**413, 1975. Data for galaxies from G. de Vaucouleurs, A. de Vaucouleurs, and H. Corwin, *Second Reference Catalogue of Bright Galaxies*, 1976. Nebular surface brightnesses estimated by D. Eicher and B. Skiff.





Left: **A finder chart for BD +34° 3815 (circled), the ninth magnitude star in central Cygnus corresponding to the powerful X-ray source Cygnus X-1. North is up, east at left — the bright star Eta (η) Cygni appears at right center. Some 2.5 kiloparsecs away, Cyg X-1 is the leading candidate for a black hole in the Milky Way.** ***Above:*** **The first X-ray photo of a star, made in 1978 by NASA's orbiting Einstein X-ray observatory, shows Cygnus X-1 in digitized form.**

and therefore extremely energetic. Astronomers had a new puzzle.

3C 273 is about 1000 megaparsecs away, yet it shines at magnitude 12.7. This means it has the luminosity of about 30 trillion Suns — an incredible output of energy. And 3C 273 measures only 5″ across on the sky, making its core region only 2.5 kiloparsecs across! (As a standard of comparison, the entire Milky Way measures some 35 kiloparsecs across.) We don't yet know definitively what quasars are, but they may likely be the intensely active centers of otherwise normal galaxies that formed long ago.

With a telescope, 3C 273 appears as an ordinary 13th magnitude star and you'll need a finder chart to locate it (see page 9). But somehow, knowing that this tiny point of light is actually one of the most energetic and puzzling objects in the universe is deeply humbling.

In 1968, two Canadian astronomers — J.M. MacLeod and B.H. Andrew — found peculiar features in the radio spectrum of **BL Lacertae**, a faint suspected variable star in the summer constellation Lacerta. When BL Lacertae was photographed with the 5-meter Hale telescope, it showed a featureless optical spectrum which led the astronomers to believe it was a white dwarf. However, in 1969, Halton Arp noticed BL Lac was nonstellar and proposed that it may be a new, unique object. BL Lacertae was certainly new, but it wasn't unique. Other such objects have since turned up in radio surveys and correspond with optical "stars." During the 1970s, astronomers hypothesized that BL Lacertae was indeed a small compact core of a much larger, fainter object — in some ways much like a quasar. It is probably 380 megaparsecs distant, and must be very small to explain its rapid fluctuations in light output. Once again, the question is how can something so small be so energetic.

BL Lac looks like 3C 273 using a medium-sized telescope — as a faint star. In fact, BL Lac varies so irregularly between magnitudes 12.5 and 16.5 that it becomes like hunting a very faint, erratic, variable star. To spot it, you'll need to use the finder chart on page 11, which shows the surrounding field down to magnitude faint stars. An interesting project might be to keep track of BL Lac's magnitude, since it can change in brightness very rapidly — sometimes within days or even hours!

So far we've surveyed exotic extragalactic objects, but now let's move back inside the Milky Way. One of the most unusual and attention-grabbing objects over the past few years has been **SS 433**, an enigmatic and bizarre "star" in Aquila. SS 433 gained attention because it showed strange, cyclical emission lines in its spectrum, which indicated a rapidly rotating object shooting dual jets of gas outward. Further, SS 433 precesses as it emits gas, leading to a corkscrew-shaped pattern of gaseous material. The latest professional consensus on SS 433 says it is a binary star system embedded in an old supernova remnant — the long-ago supernova being one of the system's stars.

SS 433 is tough to observe because it is difficult to find. Use the finder chart on page 13 to help you zero in on the correct star. Don't be surprised if you have trouble at first: SS 433 seems to irregularly vary in brightness, mainly between magnitudes 13.7 and 14.7, but sometimes erratically brightens or dims by 30 or 40 percent.

Black holes are topics of ongoing controversy and disagreement among astronomers, particularly because they cannot be seen — their presence can only be inferred from their effects on nearby luminous objects. Have you ever thought of going out and looking at a black hole? The easiest place to start is with **Cygnus X-1**, a probable black hole about half-a-degree east-northeast of Eta (η) Cygni. The star is BD +34° 3815, a ninth magnitude object easy to find with a small telescope. See the finder chart on page 12 for its location.

In June 1962, Cygnus X-1 was identified as a strong X-ray emitter using data from a NASA Aerobee rocket. In December 1970, when the *Uhuru* satellite was launched to study various X-ray objects, Cyg X-1 was a prime target. *Uhuru* found that Cyg X-1 sometimes fluctuated in X-ray emission in just 50 milliseconds. By 1973, astronomers determined that a hot stream of gas seemed to be passing from a B-type star to an unseen companion. The invisible companion would have to be in the 15 to 20 solar mass range, but the rapidity of the X-ray fluctuations meant that it must be something like 100 miles in diameter! Thus, astronomers were forced into considering a black hole candidate.

Among the Galaxy's more exotic fare are two unusual supernovae remnants, one well-observed and the other not. **Messier 1**, the famed Crab Nebula in Taurus, has probably been observed at least once by just about all deep-sky observers. M1 is the result of a supernova which occurred in 1054 A.D.; it was recorded by Amerindians and for a time outshone Venus, staying conspicuously visible in the daytime sky. Now, 930 years later, we can observe the ninth-magnitude gaseous remnant from that explosion with just a 2-inch telescope, and a large backyard instrument shows detail in the 8' x 6' oval-shaped area of M1. Less-observed is Cygnus' supernova remnant **NGC 6888**, which appears as a large dim arc of nebulosity in an 8-inch telescope under dark skies. It measures a whopping 20' x 10' across and has a surface brightness of something like 13. NGC 6888's bright central star is a hot bluish Wolf-Rayet star, one of the brightest examples of this type of object.

A finder chart for the mysterious starlike object SS 433 (between tick marks) in Aquila. The photograph is roughly centered on right ascension 19 hours 12 minutes, declination +5° 00′, and has north up, east at left. SS 433 is difficult to observe because it irregularly varies between magnitudes 13.7 and 14.7, but with a large backyard telescope it is visible with good skies. Photo by John Sanford.

NGC 2261, Hubble's Variable Nebula, is one of the finest reflection nebulae in the sky. Unlike emission nebulae, which are mostly hydrogen glowing by fluorescence, reflection nebulae are composed of dust grains and shine by reflecting starlight — they are exceedingly faint at great distances. NGC 2261 lies 800 parsecs away and measures only 0.2 parsecs across, but is visible in 6-inch scopes as a triangular smudge. It is variable because R Monocerotis, its illuminating star, changes irregularly between magnitudes 10 and 12. **NGC 1555**, Hind's Variable Nebula in Taurus, is also composed of dust grains and surrounds the variable star T Tauri. Both were discovered by the British observer J.R. Hind in 1852, who described the nebula as "faint and not exceeding 30″ in size." NGC 1555 is difficult, but should be visible on good nights with a 10-inch telescope.

The most renowned dark nebula in the sky is **Barnard 33**, the so-called Horsehead Nebula in Orion. This object probably lies 500 parsecs away, and is backlit by the faint emission nebula IC 434 just south of the bright star Zeta (ζ) Orionis at the eastern end of Orion's Belt. B33 measures some 5.5′ on the sky, corresponding to about a third of a parsec at the accepted distance. Sighting the Horsehead has always been controversial and depends on a critical combination of observer, telescope, and sky; at times it is visible with a 5-inch RFT, at other times it is, reportedly, invisible using the 40-inch Yerkes refractor! If you have dark skies and a reasonably large telescope, go out and look for it after you're dark-adapted — and keep Zeta well out of the field.

Our final exotic object is the remote globular cluster **NGC 1049** in Fornax. NGC 1049 is a member of the Fornax System, a dwarf galaxy in our Local Group about 150 kiloparsecs away from the Milky Way. Ironically, the galaxy's total magnitude is about nine, but it is so spread out that it becomes impossibly faint for small scopes due to low surface brightness. Here's a case where you can't see the galaxy, but you can spot a globular cluster within it!

The heavens have all kinds of strange, exotic fare. Tonight, we've looked at a few types of unusual objects, but there are dozens more visible to those who take the time and trouble to track them down. Let *Deep Sky* know how you did with these objects — some of them are so rarely observed (BL Lacertae, 3C 273, NGC 4319, for example) that if you find them, you'll be among a small dedicated group of exotic object hunters. Good luck!

Small Scope Showcase

Three Clusters and the Great Nebula

by David H. Levy

The sky is calling to you for a night of discovery with your new telescope. The chill in the air promises a nice dark sky, even from your backyard, and with the coming of darkness you are ready to go.

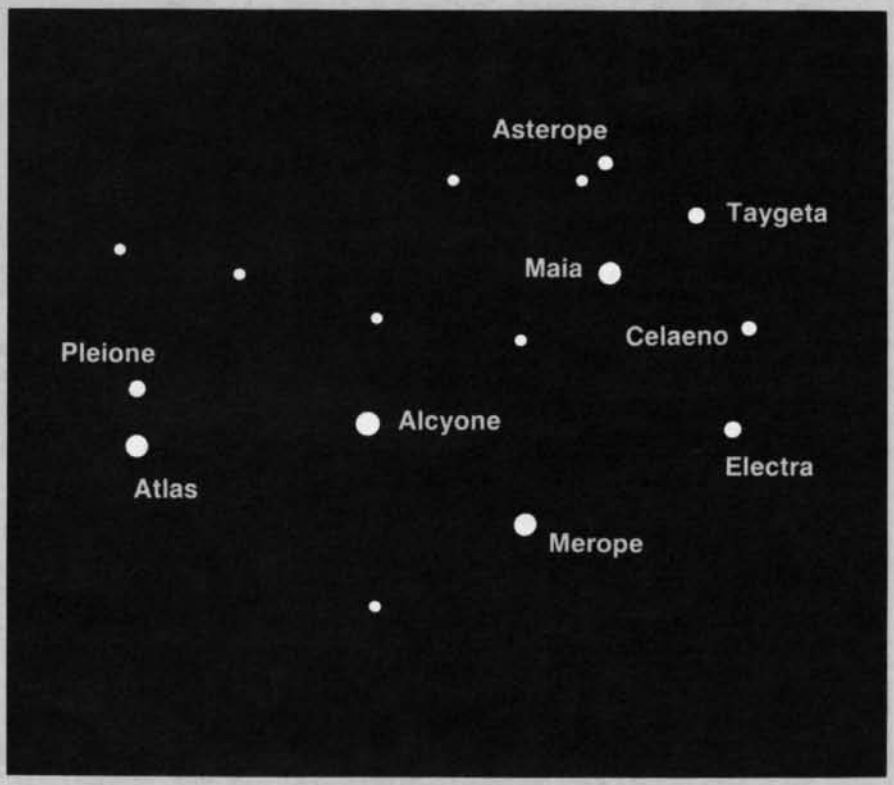
Let's begin with the **Pleiades** — one of the most famous deep-sky objects and the only one that really looks to the unaided eye like an "open cluster" of stars.

With a membership of some 500 stars, the Pleiades cluster (also known as M45) represents the kind of star grouping to which our Sun may have belonged in its youth. As star clusters and their more loosely-condensed cousins — stellar associations — revolve about the center of the Galaxy, they eventually break up from the gravitational tug of other galactic matter. In time, groups like the Pleiades will disperse, so try to observe the Pleiades tonight — in a billion years or so, they'll be completely scattered and you'll be out of luck!

The Pleiades group is 400 light-years away, which is relatively close as star clusters go. A small telescope will enable you to study and enjoy its patterns of stars and — on dark nights — cosmic dust left over from the cluster's formation. Many observers swear the best views of M45 come with binoculars, especially when these are steadied on a tripod.

How many stars can you see in the Pleiades with the naked eye? This perennial question comes from the Pleiades' mythological nickname of the "Seven Sisters." Most observers see 6 stars, a few see 8 or 9, but hardly anyone can find 7. One or more of the brighter stars may have faded half a magnitude over the past two or three thousand years.

With any optical aid, the Pleiades offers a rich clustering of stars that usually looks best at low eyepiece powers. Why? The cluster covers several square degrees of sky and to fit the entire group into one field of view calls for low magnification. The f/10 focal ratio that typical Schmidt-Cassegrains offer is something of a drawback here. A long focal ratio like f/10 almost always means a narrow field of view. If your telescope has an f/5 focal ratio, however, its field of view is relatively wide. Therefore, when you intend to observe deep-sky objects that cover a lot of sky, you'll need very long focal length eyepieces (to lower the magnification), a focal reducer to lower the f/ratio, or a short f/ratio scope to begin with.



Known since prehistoric times, the Pleiades could hardly be mistaken for a comet — yet Charles Messier placed the cluster as #45 on his list of nebulous celestial objects that might be confused with them. Curiously, on at least two occasions, experienced observers have mistaken the dusty nebulosity that surrounds Merope for a comet! Today, many find the Merope nebulosity difficult to see, but it has been picked up in instruments as small as a 2-inch; a very dark, transparent sky seems to help more than do large apertures. A favorite showpiece for every telescope owner, the blue-white stars of the Pleiades are best seen at low magnification. (North is up here, matching the view in binoculars.)

In a telescope, the argument about six or seven sisters becomes academic — you'll see hundreds of stars! If you're observing under dark rural skies, try to spot some of the dusty nebulosity that surrounds the Pleiades. You don't need a large telescope; in fact, I have glimpsed it under superb conditions with 7x50 binoculars. What's most important is to use an instrument that gives a wide field of view; this increases the contrast between the nebulosity and the surrounding dark sky. The most obvious patch of nebulosity surrounds the star Merope and much of it is conveniently offset to the south of that star. Simply move Merope away from the center of the field of view — or even out of the field entirely. If your eye is fully dark-adapted, you may get a glimpse of what has been described as being like "breath on a mirror."

Is the Pleiades the closest open cluster to us? Not at all. Just east of it is another, larger cluster called the **Hyades**, which is so close (130 light-years) that your telescope's field of view cannot show all of it at once. What you do here is sweep your telescope slowly past Aldebaran and watch dozens of stars roll by. Actually, the cluster is so widespread that it's best observed with binoculars — you need a multi-degree field to taste the cluster's splendor to the fullest.

Well, then, are the Hyades the closest open cluster to us? Again, not quite — there is at least one closer. Known as the **Ursa Major Moving Group**, this cluster of stars is near home: in fact, some of its members are conspicuously spread throughout the northern sky! Five of the bright stars in the Big Dipper are members as are such disparate stars as 21 Leo Minoris, and possibly even Alpha (α) Coronae Borealis. This cluster — at a neighborly 75 light-years

away — is indeed the closest.

Now let's turn our telescope toward a region in Perseus just south of the faint part of Cassiopeia. With a dark sky, your unaided eye may be able to see a faint smudge of light halfway between the visible stars of Perseus and Cassiopeia; it becomes a swarm of stars as soon as you look through your telescope. Nicknamed the **Double Cluster** — more officially h and Chi (χ) Persei — these two clusters-in-one are a phenomenal sight in rich-field telescopes. (With a long f/ratio telescope, use a focal reducer and a low-power eyepiece.) The western cluster (h Per) is NGC 869; the eastern (χ Per) is NGC 884. The colors and patterns formed by the multitude of stars in the two groups is amazing. Take some time to savor the view and travel — in your imagination, at least — about 7,500 light-years away.

So far we've looked at objects that require wide fields of view. Let's finish with one that looks good through *anything*: that made-for-beginners nursery of stars called the Great Nebula in Orion. More commonly known as the **Orion Nebula**, or M42, it is situated just below the three stars in Orion's belt: the nebula is the fuzzy central "star" of the sword.

With the wide field of a short-focus telescope, you can enjoy the glory of the entire nebula complete with its central "Trapezium" of four bright blue stars surrounded by brilliant hydrogen gas. With the narrower field of a long-focus telescope such as a Schmidt-Cassegrain, you'll see the center part of the nebula in greater detail — perhaps noting an extra star or two in the Trapezium and a good deal of the fine delicate structure of the gas. Many of the stars in the field are subtly variable, though it takes a lot of experience to detect their changes in brightness.

The Orion Nebula isn't so much an object to admire as a process to appreciate. Here is where new stars are being formed out of primordial hydrogen gas. The youngest members of the M42 family — hardly more than a few million years old — vary irregularly as they try to shed their stellar youth. Some 30 light-years across and 1600 light-years distant, the Orion Nebula is actually the brightest part of a star-forming factory that spreads through much of the Orion region. In 1937, one of Orion's stars — FU Orionis — brightened unexpectedly by several magnitudes. A possible explanation for this is that the star's nuclear furnace had just turned on. Such stars typify the mystery that Orion represents — a showcase of astronomy in action where you can observe a new generation of stars forming.

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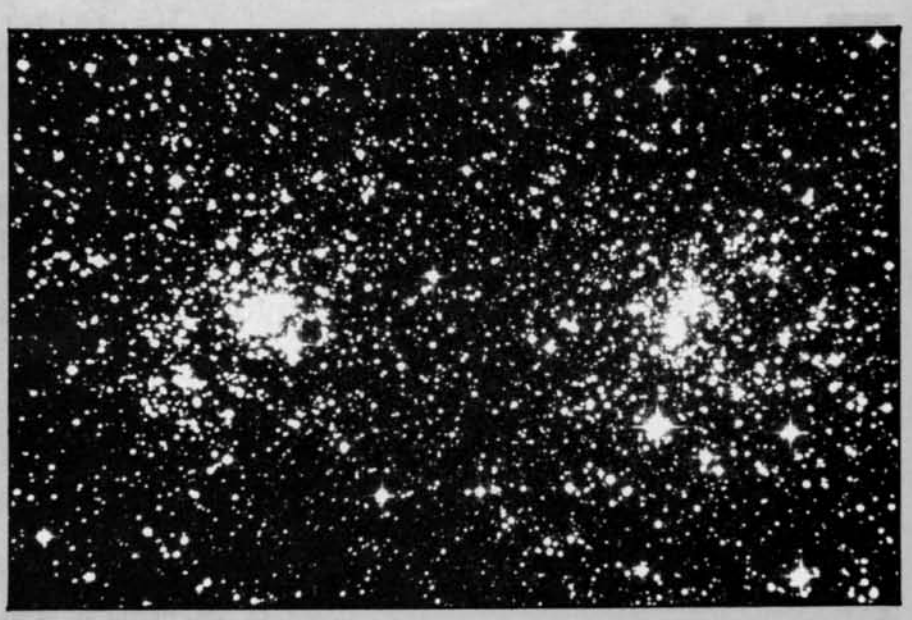


Above: NGC 884 and NGC 869 form the Double Cluster in Perseus. They lie between the naked-eye stars of Cassiopeia and Perseus, and are faintly visible to the unaided eye under good conditions. Binoculars show them in the same field, but low-power (30x to 50x) telescopes probably give the most satisfying views. Photo by Lee C. Coombs (10-inch, f/5 Newtonian; 10 minutes on 103a-O). Below: M42 and M43 together make up the Great Orion Nebula, a glorious object in any telescope. Large apertures reveal many of the faint outer parts, but even with a small scope there's lots to see here. Photo by Tom Heath (12.5-inch, f/6; 1 hour on hypered 2415 with dark red filter).

Eridanus:
From Both Sides Now

by Jim Barclay, Steve Coe, A.J. Crayon, Christian Luginbuhl, and Brian Skiff

It all began with an advertisement in *Sky and Telescope*. Australian Jim Barclay was looking for contacts with fellow amateur astronomers in the U.S., but what started out as just an overseas correspondence rapidly developed into a warm friendship between Jim and a group of observers in Arizona. We first exchanged observations of objects that lay "over the horizon" with each other. As our writing progressed, we compared observations of portions of the sky that both Americans and Australians could see. Eventually, we reached the point where we put it all down on paper.

Now before you get too far into this, take warning. Amateur astronomers in Arizona and Australia seem to share one common trait — they're all crazy about big telescopes! Therefore, you'll not see any long descriptions made with the likes of 60mm refractors or 3-inch Newtonians. Under excellent observing conditions at both of our sites, a large instrument can be used to its limit. As a result, many observers quickly graduate to large apertures. So if you are looking for deep-sky observations made with medium to large aperture scopes, you've come to the right place.

We have been observing from the rocky deserts of Arizona and the undulating hills of Queensland, Australia. Keep in mind that while we in the northern hemisphere observing Eridanus must be all bundled up to keep warm, our "mates" from Down Under are viewing these same treasures in shorts and T-shirts. (And Eridanus sweeps by virtually overhead in Australia!) The Celestial River has a good number of deep-sky goodies, so let's go dangle our feet in it.

NGC 1084: an Sc galaxy of 11th magnitude measuring 2′ x 1′. Through a 12.5-inch in Australia, a stellar nucleus is just visible at 133x and the surface brightness is low. The galaxy is elongated northeast-southwest. At 200x the nucleus is clearly visible using averted vision and remains stellar. From Arizona, some detail is lost using an instrument with the same aperture. Scopes even larger do not show as much detail as a 12-incher Down Under. The star-like nucleus is lost at any power and only faint mottling is visible across the galaxy's face. NGC 1084 lies in a fairly rich starfield with plenty of guide stars.

NGC 1140: in a 12-inch, this tiny object is only 45″ in diameter. The relatively large core is moderately brighter than the halo, about 20″ across, and contains a stellar nucleus.

NGC 1172: invisible in a 6-inch, this galaxy is not difficult in a 10-inch. The unconcentrated 30″ diameter glow lies just west-southwest of a magnitude 9.5 star. Through a 12-inch, it is 45″ across with little concentration and a low surface brightness.

NGC 1179: a 10-inch shows a tiny star-like spot with a faint halo 30″ in diameter. In a 12-inch, it is diffuse with a very low surface brightness, and small mottlings are visible around the middle of the faint irregular halo. A magnitude 13.5 star touches the halo at position angle 120°.

NGC 1187: an 11th magnitude barred spiral, about 5′ x 4′. In a medium scope from Arizona, this galaxy shows very little detail. It is somewhat brighter in the middle but no bar is visible. In a 16-inch, the nucleus is more condensed and some mottling appears. This is about the amount of detail shown by the 12.5-inch in Australia.

NGC 1199: an elliptical galaxy of 13th magnitude; it is the brightest of a small galaxy group. From Arizona, a 16-inch will show one more galaxy and the 17.5-incher two more, but these attendants are invisible with smaller scopes from either site. NGC 1199 is a small galaxy and all of our scopes show a stellar nucleus at high power. That point of light is surrounded by a dim glow and marks the rest of the galaxy's stars.

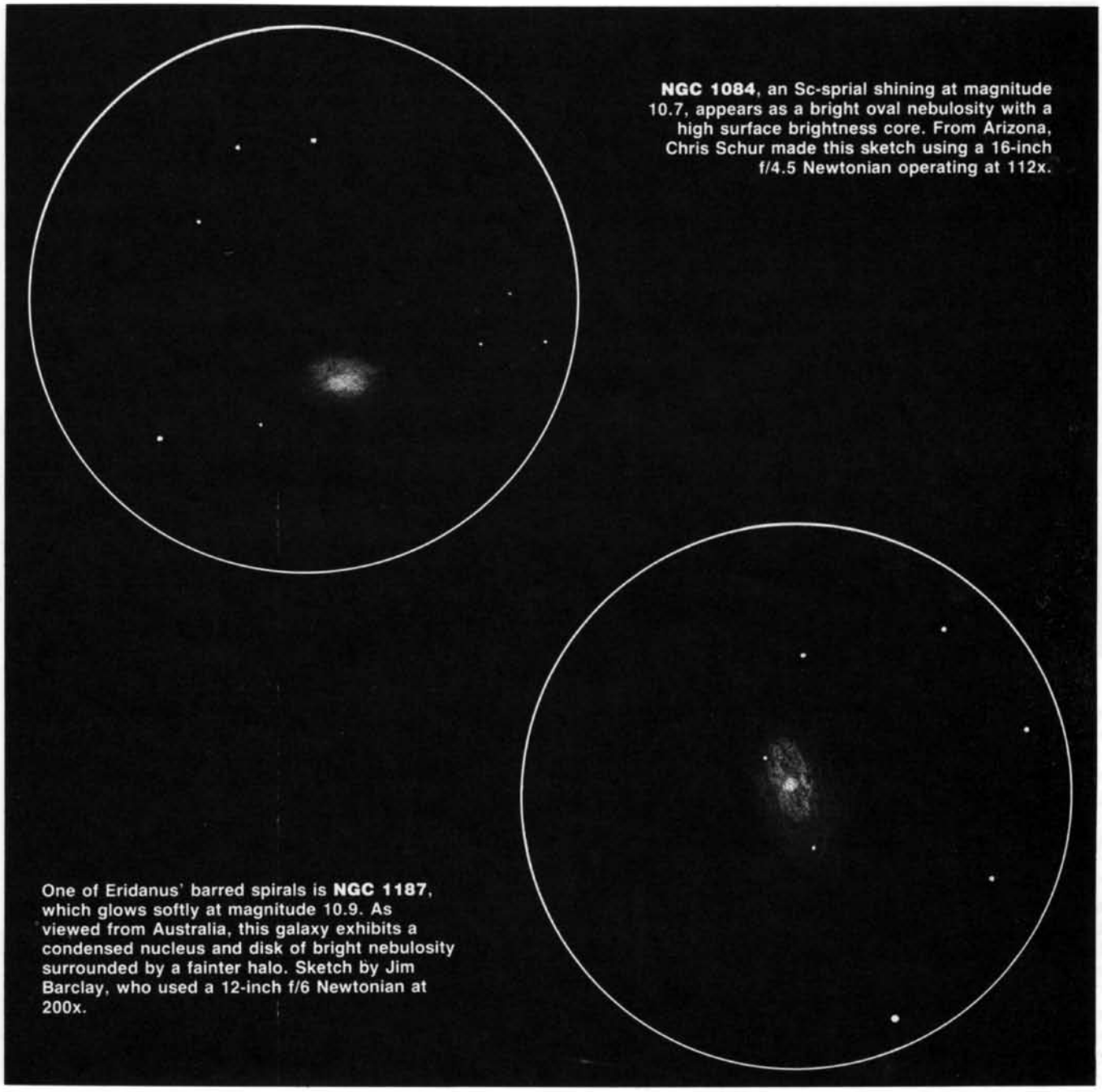
NGC 1209: a very faint object for 6-inch scopes, it appears less than 1′ in diameter with a moderately faint, star-like center. A 10-inch shows it measuring 1′ x 0.8′ in position angle 80°. The galaxy looks like an egg with a double stellar yolk: a double nucleus is clearly seen, with its eastern component being fainter. The core appears very thin; the halo is rounded and more abrupt on the western side. Through a 12-inch, it measures 1′ x 0.5′ with a 30″ diameter circular core and a nearly stellar nucleus. This galaxy is the brightest in a group that also includes NGC 1199.

NGC 1232: an excellent face-on spiral galaxy. With a 10-incher in Arizona, this object looks bright, very large, and irregularly round. At 115x it shimmers and sparkles with mottling. Several H II regions are visible with averted vision during moments of good seeing, and a bright nucleus becomes more evident with larger apertures. At 135x, a 17.5-inch shows H II regions with direct vision. These glowing objects are Orion and Eta Carinae Nebulae seen from a distance of millions of parsecs. See if your scope will bring them out on a crisp night.

NGC 1241 and **NGC 1242**: NGC 1241 can be seen only with difficulty in a 6-inch. Moderately faint in a 10-inch, the halo is circular, 1′ in diameter, with irregular edges. In a 12-inch, it is 1.5′ in diameter and evenly concentrated. NGC 1242, just visible in a 12-inch, is very small and extends only 20″ in diameter but is well concentrated.

NGC 1297: this galaxy is very small, measuring only 20″ in diameter with a 10-inch, and is quite faint but has a brighter center. In a 12-inch, the halo is 1′ in diameter with a brighter 30″ core. The galaxy is moderately concentrated with a low surface brightness.

NGC 1300: a classic example of a barred spiral. With an 8-incher at 100x, the bar is a plainly-visible elongated patch and slightly brighter in the middle.



NGC 1084, an Sc-sprial shining at magnitude 10.7, appears as a bright oval nebulosity with a high surface brightness core. From Arizona, Chris Schur made this sketch using a 16-inch f/4.5 Newtonian operating at 112x.

One of Eridanus' barred spirals is **NGC 1187**, which glows softly at magnitude 10.9. As viewed from Australia, this galaxy exhibits a condensed nucleus and disk of bright nebulosity surrounded by a fainter halo. Sketch by Jim Barclay, who used a 12-inch f/6 Newtonian at 200x.

A 16-inch instrument reveals some mottling surrounding a bright oval central condensation. NGC 1297 is a smaller and fainter companion evident in the 16-inch and 17.5-inch scopes. With averted vision on a night of excellent transparency, you can view its dim spiral arms using the 17.5-incher. A 12.5-inch in Queensland duplicates this view and reveals spiral arms trailing off a bright, elongated bar with a bright core. Often-photographed, this galaxy is a great favorite but requires good conditions for much to be seen in amateur instruments.

NGC 1309: located 4′ northeast of a magnitude 7.5 star, NGC 1309 is fairly bright in a 10-inch and has a very faint stellar nucleus inside a smooth 1.5′ diameter halo. The halo appears nearly circular in a 12-inch, is 1.5′ in diameter and elongated northeast-southwest. It shows the moderate concentration of a small nonstellar nucleus.

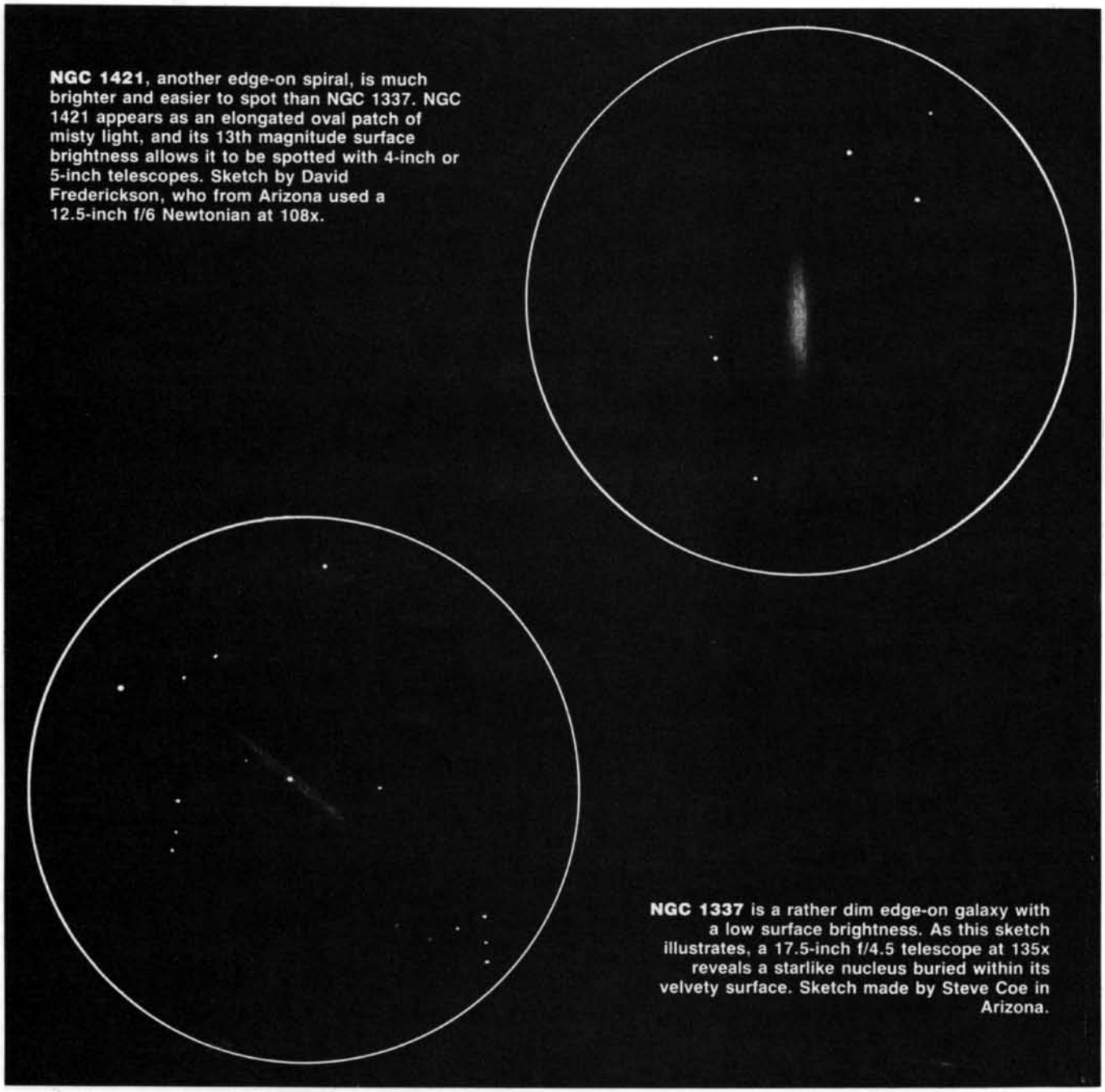
NGC 1325: though invisible in a 6-inch, a 10-inch scope shows this galaxy as a diffuse unconcentrated glow about 1′ across.

NGC 1331 and **NGC 1332**: NGC 1332 is bright in a 6-inch. The halo elongates east-west, 2′ x 0.5′, with a stellar nucleus in a very bright core. The halo is faint and extends to 2.5′ x 0.8′ in a 12-inch. The core is bright and round, 30″ diameter, with a nearly stellar nucleus. NGC 1331, though not visible in a 10-inch, appears as a star-like spot in 12-inch. It lies 2.8′ east-southeast of 1332.

NGC 1337: a dim edge-on galaxy. A 10-inch at 115x displays it as a thin streak with difficult to see central brightening. A 12.5-inch at either site does not yield much more detail. Still larger scopes make the core easier to spot and reveal it as somewhat oval and elongated northwest-southeast.

NGC 1353: a faint patch elongated northwest-southeast in a 6-inch; the halo measures 1.5′ x 0.75′. In a 10-inch, it has a thin spike-like southeastern perimeter. A 12-inch shows the halo 2′ x 0.9′, containing a circular 50″ core and a slightly brighter 20″ center.

NGC 1355 and **NGC 1358**: neither galaxy is visible in a 6-inch. A 10-inch shows NGC 1358 between two magnitude 11.5 stars. The faint halo is about 30″ diameter and exhibits only a faint stellar nucleus. A 12-inch shows



NGC 1421, another edge-on spiral, is much brighter and easier to spot than NGC 1337. NGC 1421 appears as an elongated oval patch of misty light, and its 13th magnitude surface brightness allows it to be spotted with 4-inch or 5-inch telescopes. Sketch by David Frederickson, who from Arizona used a 12.5-inch f/6 Newtonian at 108x.

NGC 1337 is a rather dim edge-on galaxy with a low surface brightness. As this sketch illustrates, a 17.5-inch f/4.5 telescope at 135x reveals a starlike nucleus buried within its velvety surface. Sketch made by Steve Coe in Arizona.

1358 in a string of magnitude 11.5 stars heading southwest from a magnitude 8.5 star. The narrow core seems elongated north-south with a stellar nucleus. The halo is irregular, mostly to the east. It is 1.5′ x 1.2′; the core is 50″ across. NGC 1355 lies 6.8′ to the north-northwest. In a 12-inch, it is very small but has a moderate surface brightness. The halo is 30″ x 12″ with a bright substellar nucleus east of center.

NGC 1357: a fairly bright object for a 10-inch, measuring 2′ x 0.75′ with a stellar nucleus. Through a 12-inch, it is 1.5′ x 1.3′ with a faint stellar nucleus that occasionally seems multiple.

IC 1953: this object lies very close to Tau[5] Eridani, but is invisible in a 6-inch. A 10-inch shows a blob 2′ in diameter. It is a very diffuse 1.1′ diameter glow in a 12-inch, brightening slightly to a 30″ core.

NGC 1359: located 4.5′ south-southwest of a magnitude 10.5 star and inconspicuous in a 10-inch, NGC 1359 appears about 1′ in diameter and a little brighter at the center. It looks stellar in a 12-inch, with a 30″ diameter haze and a magnitude 12.5 stellar nucleus.

NGC 1376: a moderately faint object in a 6-inch, about 1′ in diameter. A 10-inch shows a round dot with no central features. The irregular and uneven halo extends to 1.25′ in a 12-inch. It shows a slight concentration, but no distinct core.

NGC 1386 and **A0335-36**: a member of the Fornax I cluster, NGC 1386 is a bright galaxy in a 10-inch. The halo extends to 2′ x 0.6′. The core is about 20″ x 12″ with a faint mottled texture and a stellar nucleus. With a 12-inch, the halo is about the same size and has a low surface brightness. Lying 15′ south is A0335-36, visible in a 10-inch as a small inconspicuous spot.

NGC 1389: lying in the southwest corner of a quadrilateral containing magnitude 10 to 12 stars, a 10-inch shows the galaxy easily. The halo is about 45″ diameter, slightly elongated northeast-southwest, with a broad ill-defined core and stellar nucleus. A 12-inch shows the galaxy 3′ south of the brightest member in the quadrilateral. The halo here is 45″ diameter, also with moderate concentration but no stellar nucleus. The galaxy belongs to the Fornax I Cluster.

NGC 1395: a bright object for a

One of the most beautiful examples of a barred spiral in the sky, Eridanus' NGC 1300 shines at 10th magnitude and measures 6.5′ x 4.3′ across. It is visible in most telescopes as a fuzzy nebulosity; scopes in the 10-inch and up range begin to show detail within the galaxy's grainy halo. Photo by Jack B. Marling, who used a 17.5-inch f/4.5 Newtonian and 30-minutes exposure on hypered TP 2415.

10-inch. The halo is 1.25′ x 0.75′ with a bright and well-defined core and stellar nucleus. With a 12-inch, the halo extends to 2.2′ x 1.8′ and is elongated east-west (although a faint star embedded to the west may influence this). Overall, it has a bright nucleus nearly stellar at low magnification. NGC 1401 (magnitude 13.5) lies 21′ northeast.

NGC 1400: a 6-inch shows this moderately faint galaxy as less than 1′ in diameter with a stellar nucleus; it appears fainter than NGC 1407, 11.8′ northeast. In a 10-inch, it is 45″ across with a conspicuous stellar nucleus. The halo grows to 1.2′ diameter in a 12-inch and is slightly concentrated to a 30″ core.

NGC 1407: larger and brighter than NGC 1400 which lies 11.8′ southwest, NGC 1407 is about 1′ diameter with a bright stellar nucleus. A 10-inch shows a small core and a stellar nucleus in a 1.5′ diameter halo. The halo is about 1′ diameter in a 12-inch, with a well-concentrated core 35″ across and a very small nucleus. This galaxy is the brightest of a group that includes NGC 1400.

NGC 1415: this is a moderately faint object for a 10-inch. The halo is 1′ x 0.3′. The core is oval and has a dotted streak along its major axis. With a 10-inch, the core has darkenings around the nucleus.

NGC 1417 and **NGC 1418**: a 10-inch shows this galaxy elongated north-south, 1.2′ x 0.75′, with a sparkle or two in the center and a magnitude 11 star nearby southeast. It is small and faint in a 12-inch. The halo is 1.25′ x 1′ with a moderately brighter core 10″ across but no nucleus. NGC 1418, 5′ southeast, is visible in a 12-inch as a round, unconcentrated spot 30″ diameter 1′ north of a magnitude 13 star.

NGC 1421: a long sliver of light oriented north-south in all apertures. The 10-inch and 12.5-inch show some mottling and no discernible nucleus. Larger instruments don't seem to help a great deal.

NGC 1426: an object showing little definite detail in a 10-inch. The starry core is double; the central stellar nucleus has a nearly stellar spot on its north edge. The halo is elongated roughly southeast-northwest and about 1′ in diameter. It appears small in a 12-inch, measuring about 55″ across with a 15″ core. The nucleus is more prominent at low power.

NGC 1437: a member of the Fornax I Cluster and difficult to see in a 12-inch. This faint, uncondensed patch extends irregularly to about 2′ x 1.5′, and is unevenly bright.

NGC 1439: small and fairly faint for a 10-inch, this galaxy appears circular, 45″ diameter, with a sharp bright nucleus. In a 12-inch, it is 1′ x 0.5′ roughly north-south. The halo exhibits very little concentration except for a stellar nucleus. At 225x the nucleus loses its stellar appearance, but a faint star is visible just north of it.

NGC 1440 appears moderately faint in a 6-inch, and contains a stellar nucleus. The faint round halo is about 40″ diameter in a 10-inch; the nucleus still appears stellar. In a 12-inch at low power the nucleus is bright but nonstellar. At 225x, the halo is an elongated 1.1′ x 0.7′ and shows little concentration except for the 10″ nucleus.

NGC 1452: similar to NGC 1440, though somewhat larger. The halo is about 50″ across. It is 1′ in diameter and roughly circular in a 10-inch with a stellar nucleus. The halo is slightly elongated southeast-northwest, but the brighter parts are in position angle 45°. A 12-inch shows it 1.5′ x 1′. The nucleus is about 10″ across but appears almost stellar at 150x.

NGC 1453: a small but bright object in a 10-inch. The halo, less than 1′ diameter, has a well-defined core 30″ across and a stellar nucleus. With a 12-inch, the object is 50″ diameter and well concentrated to an 8″ core and nearly stellar nucleus. The light fades evenly to its edge.

NGC 1461: a fairly bright object for a 10-inch. It is elongated in position angle 150°, 1.5′ x 0.5′, and has an elongated core. A 12-inch shows it 1.2′ x 0.5′ with very pointed ends. The halo comes to a bright core and stellar nucleus, off-center to the north.

IC 2006: viewed in a 12-inch, this galaxy appears as a small roundish patch with splotchy concentration. The halo is about 1.25′ diameter, but at 225x it seems slightly elongated north-south. The nucleus appears nearly stellar at 150x within an irregularly bright core.

NGC 1507: barely observable in a 6-inch, it appears as a 2.5′ x 1′ patch elongated north-south. It is moderately bright in a 10-inch, extending to 3′ x 0.5′. The central area is mottled. A 12-inch shows it 3′ x 0.5′ in position angle 10°.

NGC 1518: just northeast of a magnitude 9 star, a 10-inch shows the galaxy as an elongated patch about 2′ x 0.75′ in position angle 40°. In a 12-inch the bar-like halo extends to 3.2′ x 1.0′

Photographed with the giant eye of Palomar's 5-meter reflector, NGC 1300 transforms into a highly detailed, dust-laden, knotty galaxy. The bright core is visible in most telescopes, but the largest backyard scopes may not detect any dark matter or knotty bright reigons within this spiral's arms. Photo courtesy Palomar Observatory.

and seems to fade more abruptly on the northwest. Overall, it is poorly concentrated to a faint nucleus. The inner region seems elongated about 10° closer to north-south than the halo. NGC 1521 lies 22′ east-northeast.

NGC 1521: a fairly faint galaxy for a 10-inch, located 4.3′ north of a magnitude 8 star. It appears circular, about 1.5′ diameter, with weak concentration to the core. In a 12-inch, the nucleus is nearly stellar. The brightest part of the nebula is elongated northeast-southwest, about 35″ x 25″, and its halo extends out to a 1′ diameter.

NGC 1531 and **1532**: a pair of galaxies about 2′ apart with a southerly declination. An 8- or 10-inch scope in Arizona shows 1532 as the brighter of the pair. With this size instrument, you see both the galaxy and its core as elongated (northeast-southwest). NGC 1531 is a dim patch nearby with no detail visible at any power, but elongated northwest-southeast. The core of 1532 is easier to detect with a 12.5-inch.

Moving that 12.5-inch piece of glass 12,000 miles southwest makes a striking difference. Both galaxies are readily evident at 133x with direct vision. At 190x, NGC 1531 does not show a nucleus but grows somewhat larger when viewed with averted vision. NGC 1532 is a bright streak with a nucleus that is quite visible. Averted vision reveals several H II regions in the spiral arms. From Arizona, larger scopes will not bring out that much detail even on the best of nights.

NGC 1535: the deep-sky showpiece of Eridanus. This lovely planetary nebula makes a nice break in a string of galaxies. During moments of good seeing, any aperture we used revealed a central brightening surrounded by an annular structure. The ring shape required higher powers in smaller scopes before it could be seen. High power and a large scope reveal a lot of detail in this cloud of gas: a dual ring structure became evident. The inner ring is brighter and thicker than the outer ring and we could distinctly glimpse a central star during moments of good seeing. The central star does not lie in the exact center of the bull's-eye pattern.

So far, we've avoided mentioning color, but observers have been discussing the color of NGC 1535 since William Herschel first found it two centuries ago. Our results were certainly interesting: The observer with an 8-inch saw this planetary as pale blue. Through a 10-inch and 12.5-inch in both Arizona and Australia, it was greenish. In a 16-inch, it was bluish. One observer even saw two different colors in the same scope! In a 17.5-inch, the color first appeared greenish; a season later on a sharper night, the notes say it was a lovely blue.

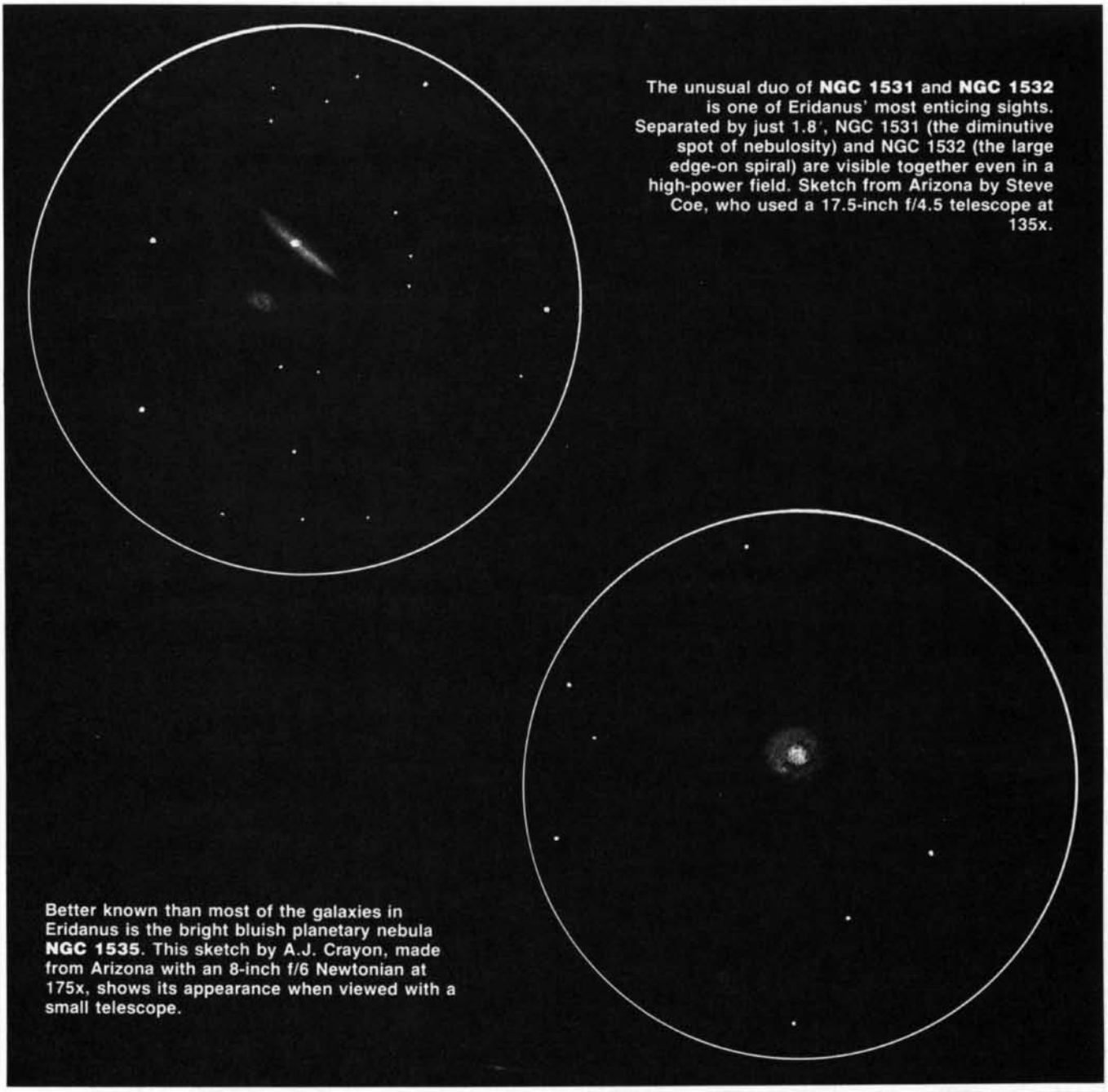
Looking through reference books doesn't help much with color, either. D'Arrest saw a light blue. *Burnham's Celestial Handbook* calls it pale bluish, and Mullaney and McCall saw blue-green (did one see blue and the other green?). It seems the color you see through your scope is the "XX-inch correct" color for that combination of observer and instrument. We hope you have fun with this one!

NGC 1537: a moderately faint object for a 6-inch. This galaxy appears round, less than 1′ in diameter, with a stellar nucleus. In a 10-inch, the halo is about 1.25′ across and averted vision shows it elongated in position angle 100° with thin spikes extending from the core. The core is very small and contains a stellar nucleus. Some faint mottlings can be seen occasionally over the object. In a 12-inch, the bright nucleus is less than 5″ across at 225x. The inner core is quite elongated in position angle 100° as is the halo. The nucleus and inner core lie closer to the north side, making that side appear more abrupt. The overall size is 1.25′ x 0.6′.

NGC 1600 and **NGC 1601**: NGC 1600 lies on the south side of a thin triangle of magnitude 7.5 stars 30′ long. It appears about 1.5′ across in a 6-inch. In a 10-inch, the smooth oval is elongated in position angle 10° with a somewhat concentrated core containing mottling at its south-southwest end. In a 12-inch, it is 1′ x 0.6′ overall with a 25″ circular core and a stellar nucleus. Lying 1.6° north-northeast is the very faint companion NGC 1601, a threshold-magnitude stellar spot in a 10-inch. NGC 1600 is the brightest of a group, which includes NGC 1601 and NGC 1603 (magnitude 15.5), lying 2.5′ east-southeast of NGC 1600.

NGC 1618: in a 12-inch, this galaxy is clearly visible lying 13′ north of Nu (ν) Eridani. The smoothly textured glow is about 2′ x 1′, elongated in position angle 30°. The halo is evenly concentrated to more circular inner regions and a faint nucleus.

NGC 1622: this galaxy lies 11′ northeast of Nu (ν) Eridani. A 12-inch shows it fairly easily despite the proximity of the bright star. A faint halo extends to about 3′ x 1′ in position angle 35°, showing a sharp but uneven central



The unusual duo of **NGC 1531** and **NGC 1532** is one of Eridanus' most enticing sights. Separated by just 1.8′, NGC 1531 (the diminutive spot of nebulosity) and NGC 1532 (the large edge-on spiral) are visible together even in a high-power field. Sketch from Arizona by Steve Coe, who used a 17.5-inch f/4.5 telescope at 135x.

Better known than most of the galaxies in Eridanus is the bright bluish planetary nebula **NGC 1535**. This sketch by A.J. Crayon, made from Arizona with an 8-inch f/6 Newtonian at 175x, shows its appearance when viewed with a small telescope.

concentration. The more circular core is about 1.5′ x 1′ with mottling within. The nucleus stands out clearly, but is not quite stellar and seems displaced a little northeast from the center of the core.

NGC 1625: the brightest of three similar galaxies near the bright star Nu (ν) Eridani. In a 10-inch, it is faintly visible at 200x as a slight brightening on the sky with a magnitude 14.5 star on the northwest. This star is clearly visible in a 12-inch, which shows the galaxy as a broad, moderately concentrated, 2′ x 0.5′ spindle elongated in position angle 130°. The magnitude 14.5 star lies 40″ northwest of center, just north of the major axis. The core is about 1.2′ long and unevenly bright, comprised of two or three brighter parts. There is no sharp nucleus. At 250x the southwest side of the halo fades more abruptly.

NGC 1637: a difficult object for a 6-inch, which shows a 2′ patch with a slight brightening in the center. The galaxy is broadly concentrated in a 10-inch, about 2.5′ across. The brighter part covers about 75 percent of NGC 1637, leaving a thin faint rim on the outside. A magnitude 13 star lies 2′ northeast of the center. In a 12-inch, the halo is unevenly bright with the most conspicuous part southeast and northeast of center. The overall size is 3′ x 2′ in position angle 45° with a 25″ core and a stellar nucleus.

NGC 1638: a faint object for a 10-inch, appearing 45″ in diameter and only slightly brighter toward a knotted center. A 12-inch shows a poorly concentrated and smooth halo measuring 1.25′ x 0.6′ in position angle 50°. There is no distinct core, but a stellar nucleus is prominent.

NGC 1640: this object forms an equilateral triangle with two magnitude 11.5 stars at 2′ distance. It is a moderately faint galaxy in a 10-inch. The oval halo brightens to a circular core. A 12-inch shows it 2′ x 1′ in position angle 50°. There is not much concentration, but the surface brightness is moderately high. The core bulges somewhat and contains a faint nucleus.

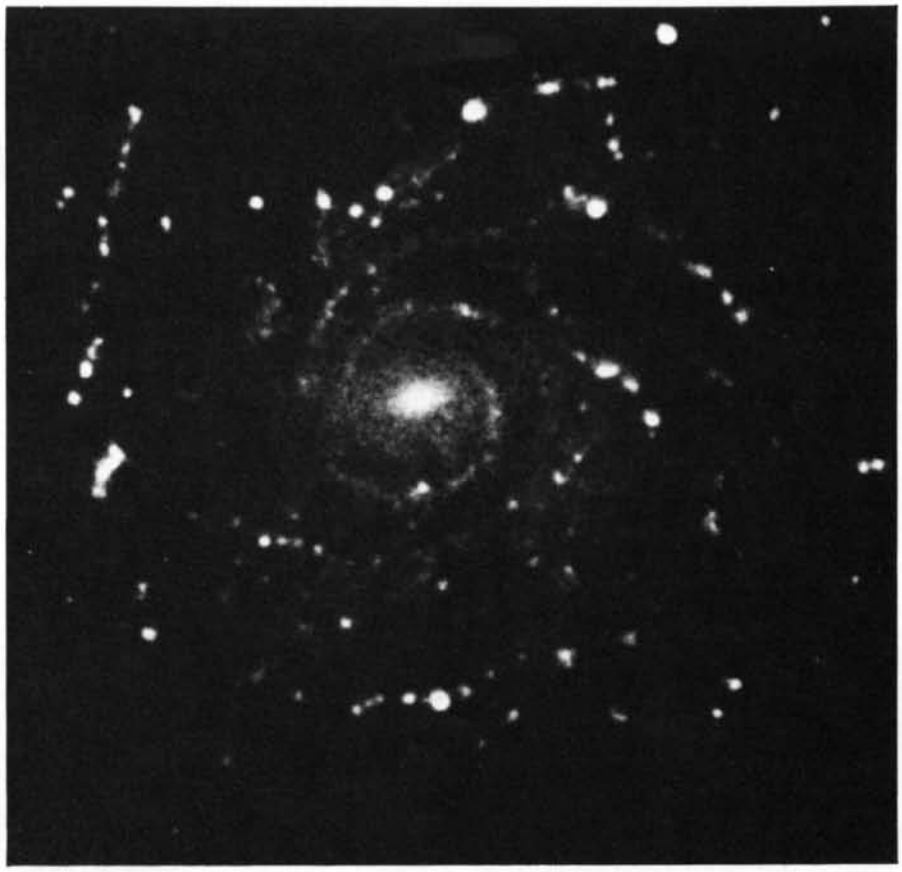
NGC 1659: a faint galaxy for a 10-inch, this object is best viewed at medium power. The halo is elongated in position angle 45°, 1′ x 0.3′, with some faint granularity in the center.

Deep-Sky Objects in Eridanus

Type	Designation	R.A. (2000.0) Dec.	Mag.	B-V	SB	Size	Sep.	P.A.	Dist.	Lin. Diam.
SAB(r)c	NGC 685	1h47.7m, −52°47′	12.0^H	—	14.8	4.1′ x 4.0′	—	—	—	—
SB(r)b	NGC 782	1h57.7m, −57°46′	12.7^H	—	14.0	2.1′ x 2.0′	—	—	—	—
SA(s)c	NGC 1084	2h45.9m, − 7°34′	10.7	0.6	12.7	2.9′ x 1.6′	—	—	19 Mpc	16 kpc
Im	NGC 1140	2h54.6m, −10°02′	12.9	0.4	12.9	1.5′ x 0.9′	—	—	20 Mpc	9 kpc
★^{2}	Theta^{1,2} ($\theta^{1,2}$)	2h58.3m, −40°18′	3.2,4.4	0.14,0.08	—	—	8.3″	88°	35.3 pc	285 AU
E1:	NGC 1172	3h01.8m, −14°50′	12.0	0.9	14.5	2.2′ x 2.0′	—	—	22 Mpc	14 kpc
SAB(r)cd	NGC 1179	3h02.0m, −18°54′	12.2^H	—	15.2	4.6′ x 3.9′	—	—	—	—
SB(r)c	NGC 1187	3h02.6m, −27°52′	10.9^H	—	14.1	5.0′ x 4.1′	—	—	18 Mpc	26 kpc
E3:	NGC 1199	3h03.7m, −15°36′	12.1	0.4	14.1	2.2′ x 1.9′	—	—	34 Mpc	22 kpc
E6:	NGC 1209	3h06.1m, −15°36′	11.4	1.0	13.8	2.6′ x 1.5′	—	—	34 Mpc	26 kpc
SAB(rs)c	NGC 1232	3h09.8m, −20°35′	9.9	0.6	14.7	7.8′ x 7.0′	—	—	22 Mpc	50 kpc
SB(rs)b	NGC 1241	3h11.2m, − 8°56′	12.7^H	—	14.4	3.0′ x 1.9′	—	—	—	—
(R)SB(s)0	NGC 1291	3h17.3m, −41°06′	8.5	0.9	14.2	10.5′ x 9.1′	—	—	9 Mpc	28 kpc
SA0$^-$:	NGC 1297	3h19.3m, −19°05′	13.0^H	—	14.2	2.3′ x 2.0′	—	—	20 Mpc	13 kpc
SB(rs)bc	NGC 1300	3h19.7m, −19°24′	10.4	07	14.5	6.5′ x 4.3′	—	—	19 Mpc	36 kpc
SA(s)bc:	NGC 1309	3h22.1m, −15°24′	11.5	0.5	13.6	2.3′ x 2.2′	—	—	30 Mpc	20 kpc
SA(s)bc	NGC 1325	3h24.5m, −21°32′	11.6	0.8	14.4	4.6′ x 1.8′	—	—	21 Mpc	28 kpc
S(s)0$^-$:	NGC 1332	3h26.3m, −21°20′	10.3	0.9	13.3	4.6′ x 1.8′	—	—	20 Mpc	27 kpc
SA(s)cd	NGC 1337	3h28.0m, − 8°24′	11.6	0.6	14.9	6.8′ x 2.1′	—	—	16 Mpc	32 kpc
SB(rs)b:	NGC 1353	3h32.0m, −20°50′	11.4	0.9	13.9	3.4′ x 1.6′	—	—	21 Mpc	21 kpc
SA(s)ab	NGC 1357	3h33.2m, −13°40′	11.7	0.9	14.0	2.5′ x 1.8′	—	—	—	—
SAB(r)0	NGC 1358	3h33.6m, − 5°06′	12.1	0.9	14.8	2.8′ x 2.1′	—	—	—	—
SB(rs)d	IC 1953	3h33.6m, −21°29′	12.3^H	—	14.2	2.8′ x 2.3′	—	—	25 Mpc	20 kpc
SB(s)m?	NGC 1359	3h33.7m, −19°31′	12.1	0.4	13.7	1.9′ x 1.6′	—	—	24 Mpc	13 kpc
SA(s)cd	NGC 1376	3h37.2m, − 5°02′	12.8^H	—	14.1	2.0′ x 1.9′	—	—	55 Mpc	32 kpc
Sa	NGC 1386	3h36.9m, −36°00′	12.3^H	—	13.9	3.5′ x 1.5′	—	—	9 Mpc	9 kpc
E4:	NGC 1389	3h37.2m, −35°45′	12.7^H	—	13.8	2.1′ x 1.4′	—	—	12 Mpc	7 kpc
E2	NGC 1395	3h38.5m, −23°01′	11.1^H	—	13.4	3.2′ x 2.5′	—	—	21 Mpc	20 kpc
SA$^-$pec	NGC 1400	3h39.5m, −18°41′	11.1	1.0	13.2	1.9′ x 1.7′	—	—	5 Mpc	3 kpc
E0	NGC 1407	3h40.1m, −18°34′	9.8	1.0	12.7	2.5′ x 2.5′	—	—	23 Mpc	17 kpc
(R)SAB(s)0	NGC 1415	3h40.8m, −22°33′	12.4^H	—	14.4	3.6′ x 2.1′	—	—	19 Mpc	20 kpc
SAB(rs)b	NGC 1417	3h42.0m, − 4°42′	12.0	0.7	14.4	2.8′ x 1.9′	—	—	55 Mpc	45 kpc
SAB(rs)bc	NGC 1421	3h42.5m, −13°31′	11.4	0.5	13.2	3.6′ x 1.0′	—	—	28 Mpc	30 kpc
E4	NGC 1426	3h42.7m, −22°07′	11.4	0.9	13.6	2.1′ x 1.5′	—	—	17 Mpc	10 kpc
SB(rs)a	NGC 1437	3h43.6m, −35°52′	12.9^H	—	14.4	2.9′ x 2.1′	—	—	14 Mpc	12 kpc
E1	NGC 1439	3h44.8m, −21°56′	12.9^H	—	14.3	2.3′ x 2.2′	—	—	25 Mpc	17 kpc
SB0(rs)0?	NGC 1440	3h45.0m, −18°18′	13.0^H	—	14.2	2.3′ x 1.9′	—	—	—	—
SB(rs)0	NGC 1457	3h45.3m, −18°38′	13.0^H	—	14.0	1.7′ x 1.5′	—	—	—	—
E2:	NGC 1453	3h46.5m, − 3°59′	11.6	1.0	13.9	2.1′ x 1.6′	—	—	51 Mpc	31 kpc
SA0$^-$(r)0	NGC 1461	3h48.4m, − 6°23′	11.7	1.1	14.1	3.3′ x 1.1′	—	—	—	—
★^{3}	32 (w,Σ470)	3h54.3m, − 2°57′	4.8,6.1,11.6	—	—	—	6.9″,166″	345°,5°	—	—
E1	IC 2006	3h54.1m, −35°59′	12.8^H	—	14.1	2.3′ x 2.1′	—	—	16 Mpc	11 kpc
pec	NGC 1487	3h55.8m, −42°22′	12.6^H	—	13.3	1.2′ x 0.6′	—	—	7 Mpc	3 kpc
SB(s)m?	NGC 1507	4h04.3m, − 2°12′	12.2	0.5	13.9	3.4′ x 1.0′	—	—	11 Mpc	11 kpc
SB(s)dm	NGC 1518	4h06.8m, −21°10′	11.8	0.5	13.7	3.0′ x 1.4′	—	—	11 Mpc	10 kpc
E3:	NGC 1521	4h08.4m, −21°03′	11.4	1.0	14.3	2.9′ x 1.9′	—	—	55 Mpc	47 kpc
E6pec?	NGC 1531	4h12.0m, −32°51′	12.1	0.7	12.9	1.3′ x 0.8′	—	—	15 Mpc	6 kpc
SB(s)ab?	NGC 1532	4h12.2m, −32°52′	11.8^H	—	13.9	5.6′ x 1.8′	—	—	15 Mpc	25 kpc
■	NGC 1535	4h14.5m, −12°45′	10.4	—	—	48″ x 42″	—	—	—	—
SO$^-$?	NGC 1537	4h13.7m, −31°33′	12.0^H	—	—	1.3′ x 0.6′	—	—	15 Mpc	6 kpc
★^{3}	Omicron^2 (40,ADS 3093)	4h15.5m, − 7°37′	4.4,9.5,11.2	—	—	—	82″,4″	104°,340°	4.0 pc	400 AU
E3	NGC 1600	4h31.7m, − 5°04′	11.1	1.0	13.7	2.5′ x 1.8′	—	—	63 Mpc	46 kpc
★^{4}	Σ571 (ADS 3328)	4h35.9m, − 3°37′	6.3,10.7, 13.6,12.6	—	—	—	18″,45″, 60″	258°,200°, 274°	—	—
SB(rs)b:	NGC 1625	4h37.1m, − 3°18′	12.7	0.8	13.1	2.7′ x 0.8′	—	—	39 Mpc	31 kpc
SAB(rs)c	NGC 1637	4h41.5m, − 2°50′	10.9	0.7	13.9	3.3′ x 2.9′	—	—	8 Mpc	8 kpc
SABO(rs)0?	NGC 1638	4h41.7m, − 1°47′	12.1	0.9	14.5	2.5′ x 1.9′	—	—	—	—
SB(r)b	NGC 1640	4h42.3m, −20°26′	11.8	0.7	14.2	2.8′ x 2.0′	—	—	19 Mpc	16 kpc
SA(r)bcpec	NGC 1659	4h46.5m, − 4°48′	12.5	0.7	13.9	1.7′ x 1.3′	—	—	59 Mpc	30 kpc
SAB(r)c	NGC 1667	4h48.6m, − 6°19′	12.1	0.7	13.3	1.5′ x 1.3′	—	—	60 Mpc	26 kpc
E4	NGC 1700	4h56.9m, − 4°51′	10.9	1.0	13.8	2.9′ x 2.0′	—	—	52 Mpc	44 kpc
SA0(s):	NGC 1726	4h59.7m, − 7°45′	12.1	1.0	13.5	1.4′ x 1.1′	—	—	—	—
□R	IC 2118	5h06.9m, − 7°13′	~8	—	~15	140′ x 40′	—	—	275 pc?	11 pc x 3 pc?

Column 1: type: ★^{2} = double star, ★^{3} = triple star, ★^{4} = quadruple star, ■ = planetary nebula, □R, = reflection nebula, Hubble types given for all galaxies. **Column 2:** name in *Revised New General Catalogue* by J. Sulentic and W. Tifft, and additional lists. **Column 3:** coordinates for epoch 2000.0. **Column 4:** V magnitude unless superscript B (= blue magnitude) or superscript H (= Harvard photographic magnitude). **Column 5:** B-V = integrated color: the higher the number, the redder the object. **Column 6:** surface brightness in magnitudes per square arcminute. **Column 7:** size in arcminutes or arcseconds. **Column 8:** separation in arcseconds. **Column 9:** position angle in degrees. **Column 10:** distance in parsecs or megaparsecs. **Column 11:** linear diameter in astronomical units, parsecs, or kiloparsecs. Data for double stars from the Lick Observatory *Catalogue*. Data for galaxies from the *Second Reference Catalogue of Bright Galaxies*, by G. de Vaucouleurs, A. de Vaucouleurs, and H. Corwin. Magnitude data for IC 2118 estimated by D. Eicher and B. Skiff.

Although the delicate spiral structure is difficult to observe visually, NGC 1232 is one of the prettiest face-on spiral galaxies in the sky. Backyard telescopes show a tiny core surrounded by low surface brightness haze. Kitt Peak 2.1-meter telescope photo courtesy Paul Hodge.



Many stars are visible in a 40′ field surrounding the nebula. High power gives a better view in a 12-inch. The object measures 1.2′ x 0.8′ in position angle 45°, with a stellar nucleus showing the only brightening except for a tiny region immediately around it. The halo is mottled, has fairly definite edges, and moderate surface brightness.

NGC 1667: faintly visible in a 6-inch, this galaxy appears as a uniform 1′ glow that is slightly elongated north-south. A 10-inch shows a 1.5′ x 1′ oval in position angle 170° with some mottling visible in the core. A magnitude 14.5 stars lies 1.7′ southwest. In a 12-inch, the halo is 1′ x 0.8′ with weak uneven concentration to a faint nucleus. Photographs shows NGC 1666 (magnitude 13.5) 15′ south.

NGC 1700: with a bright star 7′ northwest, this galaxy is an easy object for a 6-inch. It is about 1′ in diameter and brightens a little toward the center. In a 10-inch, the core is nearly stellar in a 45″ x 30″ halo. A 12-inch shows a high surface brightness halo, a smaller brighter core about 15″ across, and a stellar nucleus. The halo extends to 1′ x 0.75′ in position angle 80°, fading little from the center to the fairly definite edge. NGC 1699 (magnitude 15) lies 6.5′ north.

NGC 1726: a 40″ spot without detail at high power in a 6-inch. A magnitude 12 star lies 50″ south of center. A 10-inch shows it 1.2′ x 0.5′, elongated north-south with a stellar nucleus inside a smooth halo. In a 12-inch the galaxy is less than 1′ diameter, but the south star interferes with determining the elongation. Two magnitude 9 stars lie about 5′ southeast and west-southwest. NGC 1720 (magnitude 13) lies 8.2′ southwest.

NGC 1741AB and **IC 399**: this complex interacting system is too faint for a 6-inch. In a 12-inch, NGC 1741AB is a small fairly faint glow about 40″ x 20″ in size elongated roughly east-west. A substellar point stands out near the center and a faint mottling is discernible at the west edge. This latter point is the A component; the rest is the B component. A magnitude 11.5 star lies 1′ southeast. In a 12-inch, it is a small but weakly and evenly concentrated spot about 25″ diameter.

As a group we have always enjoyed a nicely tinted multiple star, so here are some examples for Eridanus.

Struve 571: a 6th and 11th magnitude pair separated by 17″. Any scope we used split the pair easily at 100x and revealed the brighter star as white and its companion as bluish.

32 Eridani: a 5th and 6th magnitude pair separated by 7″. Again, 100x split them easily and all observers saw their colors as golden and bluish.

Theta (θ) **Eridani**: a 4th and 5th magnitude binary with an 8″ separation. On a steady night, the colors are subtle but generally appear creamy and bluish. This one is much easier seen from Down Under.

Omicron² (o^2) **Eridani**: a fine triple system of magnitudes 4, 9, and 11. The separation between components is 82″ and 8″. The secondary is a white dwarf and one of the easiest to see in small scopes. The third member is a red dwarf, making this a very unusual system. Even though observers on both continents differed in their description, we can draw some general conclusions concerning the colors in this lovely triple system. The primary is whitish, the secondary is blue, and the third is dull red. This agrees remarkably well with T.W. Webb's description from a century ago. The colors also match the physical system with uncanny accuracy.

* * *

So much for Eridanus. We've already begun accumulating more observations on other constellations. Coordinating observers half a world apart takes a lot of time, so here's what we're working on: Centaurus, Scutum, Aquarius, and Canis Major. If you are the proud owner of a bulging observing log, how about sharing some of that wealth with the rest of us? If you have descriptions, photos, or comments, please send them to us care of *Deep Sky*.

You know, it's almost as much fun to read about astronomy as it is to do it. That's why nature invented the Full Moon and cloudy nights — when else would you catch up on your reading? And besides, it also gives you time to get re-acquainted with your spouse and kids!

Jim Barclay lives in Manly, Queensland, Australia and has been a deep-sky fanatic since 1957. Steve Coe and A.J. Crayon live in Phoenix, Arizona and have been observing deep-sky objects for several years. Christian Luginbuhl lives in Flagstaff, Arizona and works at the U.S. Naval Observatory. Brian Skiff also lives in Flagstaff and works at Lowell Observatory.

Observing Small Nebulae Part 1

by Chris Schur

Although it is less brilliant than its summer counterpart, the winter Milky Way still has its well-known showpieces — the Orion Nebula, the Double Cluster, M41, and so on. Besides these celestial landmarks, the winter sky also harbors a fine collection of small nebulae that invites exploration. While not exactly *terrae incognitae* — two were logged by Messier himself and the rest are in the *New General Catalogue* or their supplementary *Index Catalogues*, these objects are usually ignored by all those backyard observers who think the greenish glow of Orion's M42 is the only winter deep-sky object worth braving the cold for.

Let's broaden the horizons a bit and check out the *other* sights — those small nebulae that continue to lure back generations of experienced observers who've learned that the greatest rewards are often found in inconspicuous or unexpected places.

But first, what exactly *are* these "small nebulae" and where do they lie? In general, we are talking about relatively small clouds of gas and dust that either emit monochromatic light (chiefly from ionized hydrogen gas) or reflect a broad continuum of starlight from some nearby stellar beacon. As we'll see, some objects manage to combine both features. Generally ranging in size from 10 arcminutes' diameter or less, they are plotted on the *Sky Atlas 2000.0* or the older *Skalnate Pleso Atlas of the Heavens* as small green boxes. Either of these atlases will make nebula-hunting a lot easier.

Most of these nebulae lie in either the Sagittarius/Scorpius part of the Milky Way or the Orion/Monoceros region. Since it's winter now, we'll start our two-part journey in the Orion section — next summer, we'll explore Sagittarius.

The constellation of Orion itself contains perhaps the best sampling of both reflection and emission nebulae — though they are easily overlooked because of such splendors as M42. For example, **M43** (also known as NGC 1982) is usually considered a small detached portion of its larger neighbor, the Great Orion Nebula. This spectacular interstellar cloud contains both emission and reflection nebulosities: it is one of the few deep-sky objects that appears just as breathtaking at the eyepiece as it does in long-exposure photographs. In my 16-inch Newtonian, M43 consists of an eighth-magnitude star surrounded by an inner disk and an outer ring, both separated by a dark lane. The inner disk is slightly oval, but is otherwise featureless; the outer ring is broken on the east side by a sizable dark notch. The ring also contains thick dust lanes of obscuring material. My nebular filter (a Lumicon UHC) enhances only specific portions of the object, confirming that it indeed shines by an mixture of emission and reflection light.

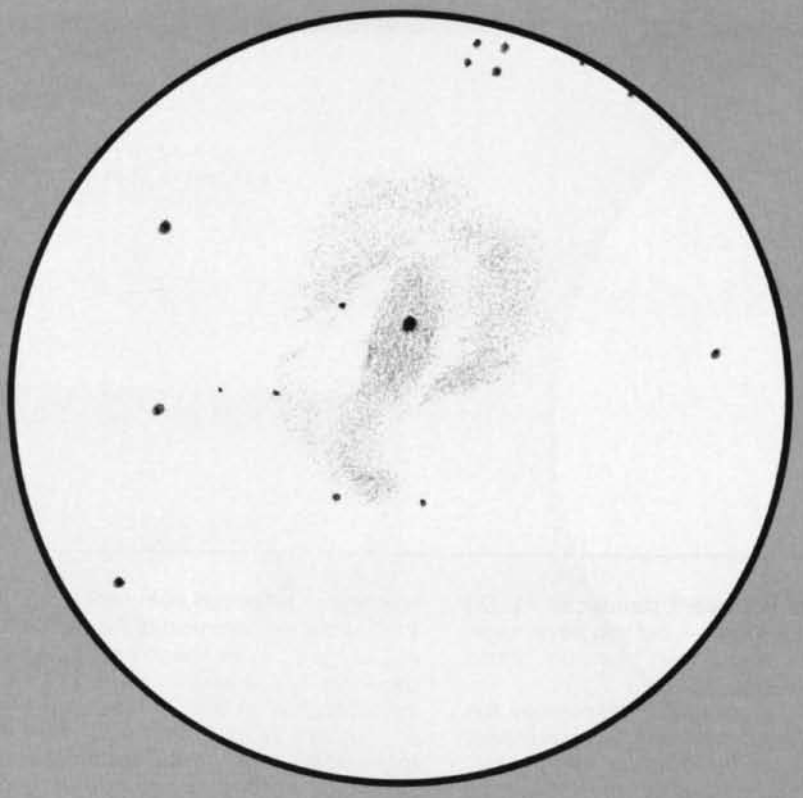
Most of Orion is wreathed in hydrogen gas, which shows clearly in this red-light photo by Jack Marling (50mm f/1.8 lens, $H\alpha$ filter, hypered 2415, 1 hour exposure).

A few degrees south of M43 lies **NGC 1999**. Despite being one of the brightest reflection nebulae, this object is usually missed when people sweep their telescopes through the Sword region. Yet if you have a 6-inch or larger scope, it's worth the effort. NGC 1999 appears as a tenth-magnitude star encompassed by a circular nebulous cloud about 5′ across. Condensed in the center, the real attraction of this celestial splendor becomes visible at higher magnifications with averted vision. You can then see dark patches or lanes on the western side of its perfectly spherical glow. Since NGC 1999 shines by reflected starlight, nebular filters only seem to make it dimmer.

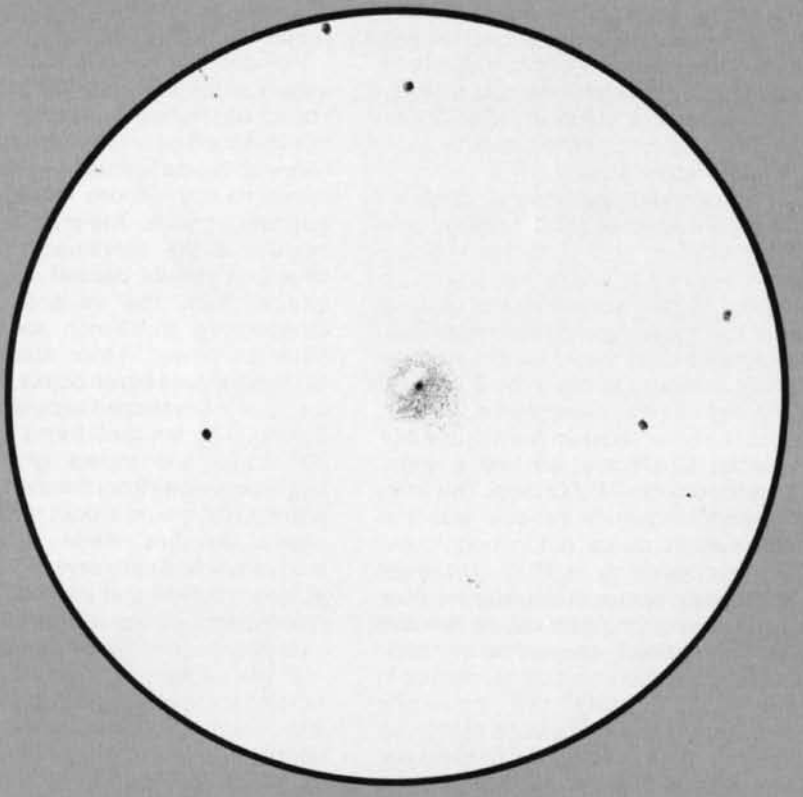
Moving several degrees northeast of the Sword complex, we find **M78**. This consists of an intriguing combination of reflection and dark nebulosities, measuring 8′ by 6′. Beaming brightly at eighth-magnitude, M78 resembles a circular glow with the north end cut flat by a dark-obscuring dust lane. The nucleus contains two tenth-magnitude stars some 53″ apart. Just north of the dark lane is the other detached portion of M78. Known as **NGC 2067**, this section has been sometimes called the "Handsaw Nebula" because of its long, tapered shape. Just west of M78 you may be able to see another very faint hazy patch, which is **NGC 2064**. This has nearly the same dimensions as M78, but to see it clearly you'll need a dark night, a transparent sky, and you must use averted vision with at least 8-inches of aperture.

About half a degree north of M78 is the reflection nebula **NGC 2071**. Looking much like an eleventh-magnitude star surrounded by a misty glow 4′ in size, the complex offers interesting comparisons of the diversity of forms you can find in reflection nebulae.

Near Zeta (ζ) Orionis, the star at the eastern end of the Belt, and within a degree of the famous Horsehead Nebula, are three easy-to-spot reflection nebulae. The brightest of the trio is **IC 435**, an easily-found IC object. (This is



Left: **At 180x in the eyepiece of a 16-inch, M43 shows luminous patches interspersed with a few dark lanes of dust. (All sketches by the author.) In the photo below, the luminous area is larger and dusty regions more intricate. Photo by Martin C. Germano (8-inch SCT, f/10, 103a-F, 25 minutes).**



Above: **Notoriously difficult to see, the Horsehead Nebula (B 33) calls for extremely transparent dark skies. Photo by Martin C. Germano (8-inch SCT, f/10, 103a-F, 2 hours).** ***Right:*** **NGC 1999 lies close to M43, but is often overlooked (16-inch Newtonian, 180x).**

unusual because most IC listings are quite faint.) This small, round, bluish reflection cloud encircles a ninth-magnitude B8-type star and measures about 3′ across. It is virtually featureless in small aperture telescopes.

This object, however, is much brighter than the nearby **IC 432**, due north of ζ Orionis. Engulfing a seventh-magnitude bluish star, this nebulosity is under 5′ in size and needs moderate to high magnification to reveal its internal details. Just 10′ to the west is **IC 431**, another faint spherical glow surrounding a tenth-magnitude star. Nearly touching this nebulosity and completing the scene is an eighth-magnitude orange star.

Moving southeast of the IC trio, we find **NGC 2023** — a bright reflection nebula in the same ζ Orionis complex. Appearing as a bright, medium-sized circular patch, it is condensed toward the center where an eighth-magnitude star lies. A dark dust lane cuts off one-fourth of its western side. NGC 2023's high surface brightness allows the use of high magnifications.

Ten degrees west and 2° north of Beta (β) Eridani is **NGC 1788**. At low magnification, this reflection nebula looks like a small galaxy. Two faint stars appear to be involved in the glowing mist that resembles an elongated oval along the axis of the two faint stars. The entire nebula is about 8′ by 5′ in size.

In the northern end of the Hunter, about halfway between Betelgeuse and Lambda (λ) Orionis, we find a rather peculiar object — FU Orionis. This is an eleventh-magnitude variable star that occasionally bursts out in brightness: the last occurring in 1937. The most interesting feature of this star involves the accompanying dark nebula **Barnard 35**. This normally appears as a circular starless void about a quarter degree in diameter. During the nova-like outbursts, these dark clouds light up as the wavefronts from FU Ori hit them and are reflected toward us. From the backyard observer's standpoint, FU Ori isn't much to see — but you never know when it'll pop off and "turn on" those clouds of dust again.

Moving eastward into Monoceros, the Milky Way grows richer. Large numbers of small nebulae lie in this region, allowing direct comparisons of several objects in the same field. **NGC 2245** and **NGC 2247** are a pair of reflection nebulae, about a quarter-degree apart on a north-south line. As seen in an 8-inch, the former is the northernmost member and appears as a 5′ diameter nebulosity around an eleventh-magnitude star; it is slightly condensed toward the middle where a bluish central star lies. In the same low-power field is NGC 2245, a 3′ x 5′ comet-shaped reflection nebulosity with an eleventh-magnitude star at its center. NGC 2245 is bright and easily spotted in an 8-inch scope.

Perhaps the finest small reflection nebula in the area is **NGC 2261**. Also known as Hubble's Variable Nebula, this object offers an opportunity for true research by the amateur — especially those having scopes of 12-inches' aperture or more. The main feature of interest is the continually changing structural details caused by shadow effects from the variable star R Monocerotis. In 16-inch apertures at moderate power, R Mon appears as a tenth-magnitude bluish object located at the tip of a fan-shaped nebulosity some 2′ long. The fan itself forms a striking 30° angle and tapers gradually in brightness away from the star. As seen with averted vision, it looks mottled, and careful sketches, made at one year intervals, will usually reveal changes in its basic outline and internal details. I recommend you use at least 150x to get a large enough scale for your drawings.

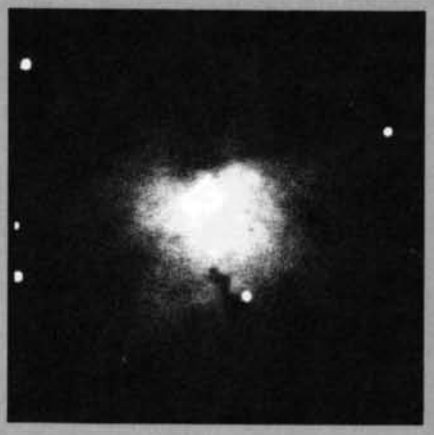
If you've had little or no difficulty locating these objects, swing your scope into southern Monoceros. Look a degree east of Gamma (γ) Monocerotis for **NGCs 2183** and **2185** — two faint patches of reflection nebulosity. NGC 2183 is the westernmost of the pair and at first glance looks like three faint stars patterned in a small triangle. Encircled by softly glowing mist, it is a moderate 5′ in extent. NGC 2185 lies just a little to the east and is a small patch of faint nebulosity with only a very faint twelfth-magnitude central star.

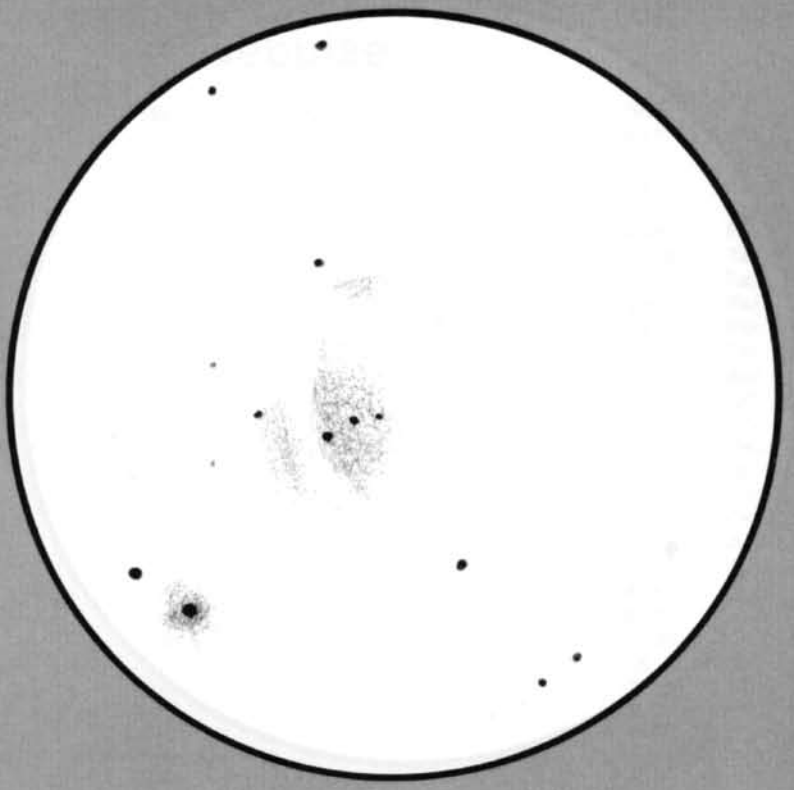
On the other side of NGC 2183, about a degree away, is the **NGC 2170** complex: a complicated region of interconnected bright and dark nebulosities best viewed with a wide-field eyepiece. NGC 2170 itself consists of two ninth-magnitude reflection nebulae. Several bright knots can be seen just to the east, but a long-exposure photo would be required to bring out all that's there.

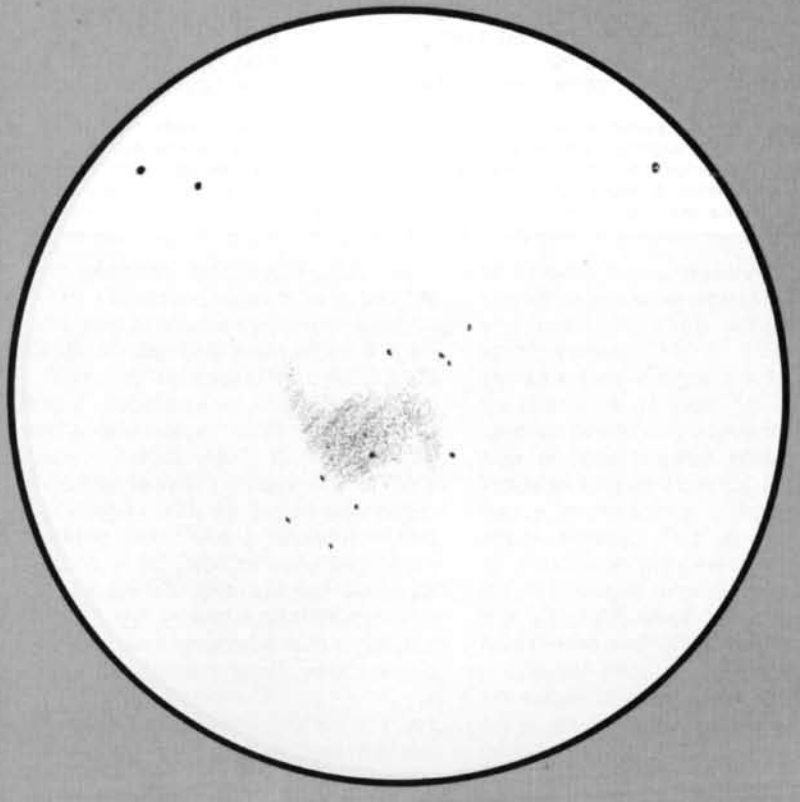
After the Crab Nebula, **NGC 2359** and **IC 468** in Canis Major are two of my most studied objects. Both lie about 4° northwest of Gamma (γ) Canis Majoris. NGC 2359 consists of an eleventh magnitude blue-white Wolf-Rayet star surrounded by a huge cosmic bubble of expanding gases that is plowing into both the interstellar medium and some associated emission nebulosity. The result is a most interesting object with wispy extensions and long glowing filaments. My best views have been at low magnification with the UHC filter under very transparent sky conditions. But you needn't always stick to low powers since this 8′-long object seems to bear higher magnification well. At 200x in my 16-inch, the main body appears as a round hollow shell with wisps of material faintly visible inside.

The wedge-shaped nebulosity looks very much like the long and tapered head of a tropical bird. When you combine this with a long, curved thin gas streamer on the opposite side of the bubble, you can see how NGC 2359 earned the nickname some friends and I have given it: the Toucan Nebula. Buried in its wedge-shaped "head," it even contains a bright ninth-magnitude

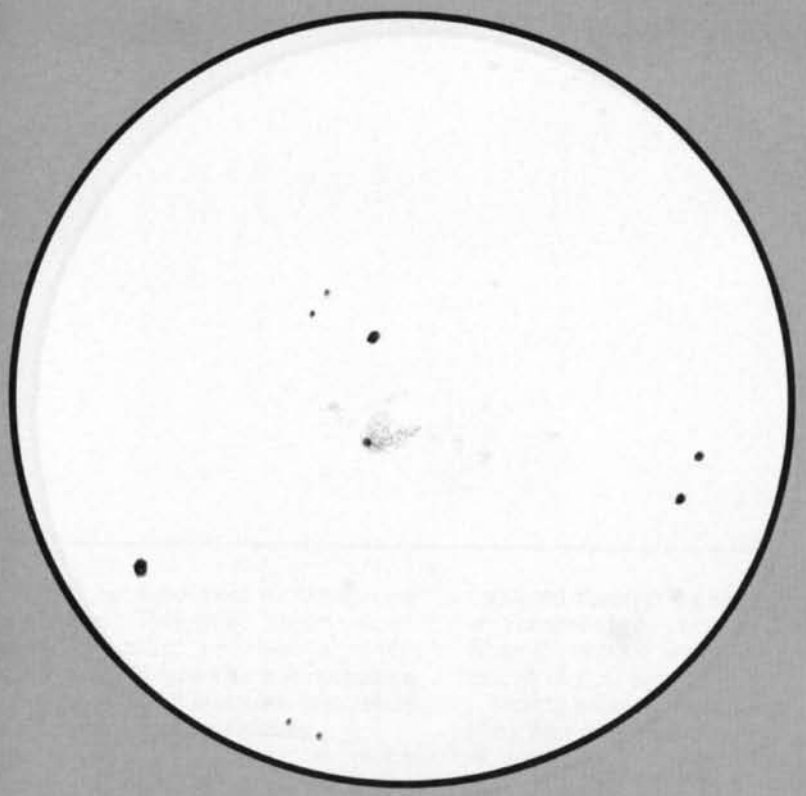
Right: **M78 — a fairly dim reflection nebula discovered by Pierre Mechain in 1780 and included by Messier in his famous list (16-inch Newtonian, 90x).**
Below: **NGC 2023 lies among the nebulosities surrounding Zeta Orionis. Photo by Martin C. Germano (8-inch SCT, f/10, 103a-F, 84 minutes).**



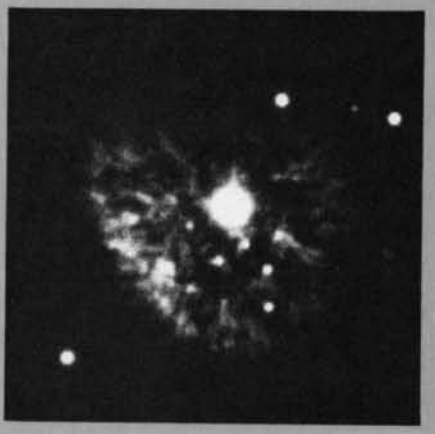


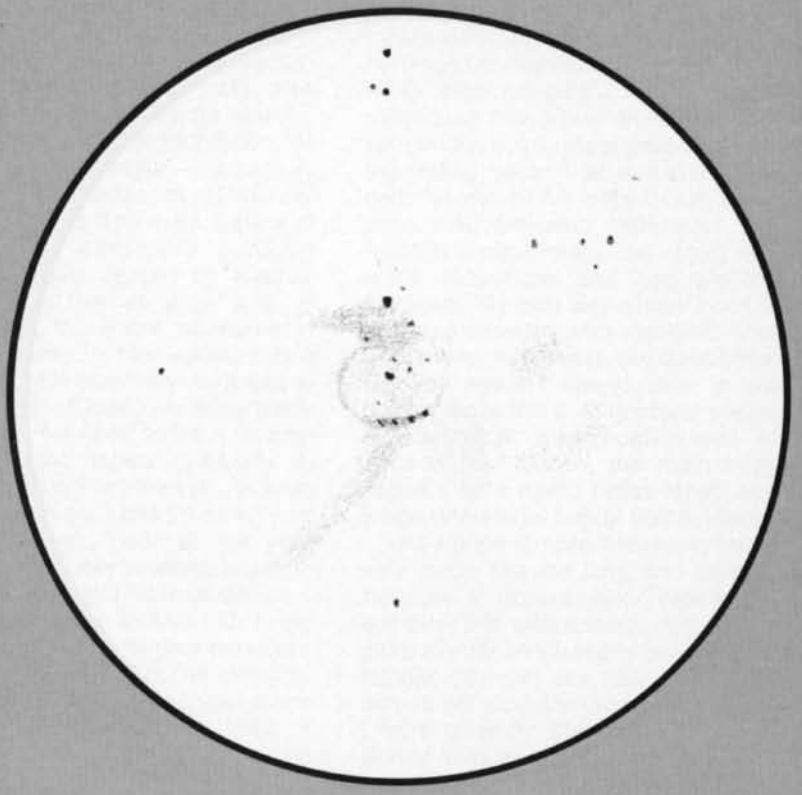


Left: **Though nowhere as bright or easy to find as the Orion Nebula, the supernova remnant M1 — the Crab Nebula — is one of the most famous and studied objects in the sky (16-inch Newtonian, 180x). Another member of the Zeta Orionis complex is IC 431, shown above. Photo by John Parker (5.5-inch Schmidt, f/1.65, hypered 2415, Wratten #92 filter, 30 minutes).**



Left: Hubble's Variable Nebula (NGC 2261) is a fan-shaped spray of light illuminated at its tip by the flickering variable star R Monocerotis (16-inch Newtonian, 180x). ***Below:*** Long after the eruption of GK Persei, the star that gave rise to Nova Persei 1901, a shell of thrown-off gas became visible. Photo taken in late 1949 with the 200-inch Hale telescope.





Right: NGC 2359 is a complex tangle of gas surrounding a Wolf-Rayet star; dimmer IC 468 lies immediately adjacent (16-inch, 90x, UHC filter). ***Above:*** NGC 1931 is a diminutive nebula in Auriga, but displays detail when viewed with high power. Photo by Brian Skiff, using the 13-inch astrographic "Pluto" camera at Lowell Observatory.

Winter's Small Nebulae

Type	Object	R.A. (2000) Dec.	Mag.	Mag.*	SB	Size	Con
□R	NGC 1333	3h29.2m, +31°22′	10	10.8	13	9′x7′	Per
NR	GK/N1901	3h31.2m, +43°54′	—	11↔14	—	—	Per
□R	IC 1995	3h50.3m, +25°35′	—	5.4	—	2′x2′	Tau
□R	IC 353	3h53.5m, +25°41′	—	7.2	—	2′x2′	Tau
□E	NGC 1491	4h03.3m, +51°18′	10	11.0	13	9′x6′	Per
□ER	IC 359	4h20.2m, +28°13′	—	12.5	—	15′x10′	Tau
□R	NGC 1554/5	4h22.8m, +19°32′	10(v)	9↔13	—	—	Tau
□R	NGC 1579	4h30.2m, +35°17′	11	17.0	13.5	12′x8′	Per
□E	NGC 1624	4h40.3m, +50°27′	13	12.0	14	5′x5′	Per
□R	NGC 1788	5h06.9m, −03°20′	9	10.1	12.5	8′x5′	Ori
□E	NGC 1931	5h31.4m, +34°15′	11	11.5	13.5	4′x4′	Aur
□R	IC 423	5h33.5m, −00°37′	—	—	—	2′x2′	Ori
—	IC 424	5h33.6m, −00°19′	—	—	—	2′x1′	Ori
SNR	M1 (NGC 1952)	5h34.5m, +22°01′	—	15.9	—	8′x6′	Tau
□ER	M43 (NGC 1982)	5h35.5m, −05°16′	7	6.8	12	20′x15′	Ori
□R	NGC 1999	5h36.5m, −06°43′	9	10.4	12.5	2′x2′	Ori
□R	IC 426	5h36.8m, −00°14′	—	9.3	—	10′x3′	Ori
—	NGC 1985	5h37.7m, +31°59′	—	13.3	—	1′x1′	Aur
□R	IC 430	5h38.6m, −07°04′	—	4.9	—	11′x11′	Ori
□R	IC 431	5h40.4m, −01°27′	12	7.8	15	8′x5′	Ori
□R	IC 432	5h41.0m, −01°29′	11	7.1	14	10′x10′	Ori
□E	IC 434	5h41.1m, −02°25′	9	—	13.5	90′x30′	Ori
□D	Barnard 33	5h41.2m, −02°31′	—	—	—	5′	Ori
□R	NGC 2023	5h41.7m, −02°14′	9	7.8	13	10′x8′	Ori
□R	IC 435	5h43.0m, −02°19′	—	8.2	—	4′x3′	Ori
□D	Barnard 35	5h45.3m, +09°04′	—	—	—	—	Ori
□R	M78 (NGC 2068)	5h46.7m, +00°03′	8	10.2	13	8′x6′	Ori
□R	NGC 2071	5h47.1m, +00°18′	—	10.1	—	7′x5′	Ori
□R	NGC 2170	6h07.7m, −06°23′	12	10.2	14	2′x2′	Mon
□R	NGC 2182	6h09.5m, −06°20′	12	9.1	14	3′x2′	Mon
□R	NGC 2183	6h10.8m, −06°13′	12	13.5	14	2′x2′	Mon
□R	NGC 2185	6h11.1m, −06°13′	12	12.5	14	2′x2′	Mon
□E	IC 2162	6h13.3m, +18°08′	—	10.0	—	4′x4′	Ori
□R	IC 444	6h20.5m, +23°18′	—	7.0	—	8′x4′	Gem
□R	IC 446	6h30.8m, +10°27′	—	10.5	—	5′x4′	Mon
□R	IC 2167	6h31.0m, +10°27′	14	11.0	—	2′x1′	Mon
□R	IC 2169	6h31.1m, +10°01′	13	8.5	—	25′x20′	Mon
□ER	NGC 2245	6h32.7m, +10°10′	—	—	—	2′x2′	Mon
□ER	NGC 2247	6h33.0m, +10°20′	10	8.5	12.5	2′x2′	Mon
□R	NGC 2261	6h39.1m, +08°43′	9(v)	13(v)	12.5(v)	2′x1′	Mon
□R	NGC 2282	6h46.8m, +01°20′	11	9.7	13	3′x3′	Mon
—	IC 466	7h06.7m, −04°20′	—	10.5	—	1′x1′	Mon
□E	IC 468	7h17.5m, −13°10′	9	10.4	13	20′x20′	CMa
□E	NGC 2359	7h17.7m, −13°13′	—	10.4	—	10′x5′	CMa
□E	NGC 2467	7h53.4m, −26°24′	8	8.5	13	8′x7′	Pup
□R	NGC 2626	8h35.6m, −40°38′	—	9.4	—	—	Vel

Column 1: object type: □E = emission nebula, □R = reflection nebula, □D = dark nebula, □ER = complex nebulosity, NR = nova remnant, SNR = supernova remnant; **Column 2:** name in *Revised New General Catalogue*, by J. Sulentic and W. Tifft, and additional lists; **Column 3:** coordinates for epoch 2000.0; **Column 4:** integrated magnitude; **Column 5:** magnitude of illuminating star in V system; **Column 6:** nebular surface brightness in magnitudes per square arcminute; **Column 7:** angular size in arcminutes; **Column 8:** constellation in which object lies. Dimensions and central star magnitude data from B. T. Lynds, Kitt Peak National Observatory. Nebular magnitudes and surface brightnesses estimated by D. Eicher and B. Skiff.

star denoting an "eye"! Just west, about a quarter-degree from it, lies the faint glow of a more extended object — IC 468 — also best seen with the filter.

Some 15° southeast from NGC 2359 and 2° southeast of Xi (ξ) Puppis, we find another object worthy of repeated study — **NGC 2467**. A medium-size spherical nebula, it measures 5′ or more in diameter with an 8-inch telescope. Looking much like a miniature Trifid Nebula, NGC 2467 reveals dark lanes — though it'll take averted vision to detect them — and a tenth-magnitude central star. Impressive with a nebular filter, this emission nebula will draw you back time after time.

For our final sampling, let's turn to **M1** in Taurus. Known as the Crab Nebula, this supernova remnant emits radiation at virtually every wavelength known. Depending on what type of nebular filter you use, the Crab takes on new appearances. This 5′ by 3′ nebula shines at ninth-magnitude. Viewed with no filter in a 16-inch, M1 is large at medium power and appears double the size of most typical small nebulae. Twice as long as it is wide, M1 gives the vague impression of a slightly inclined spiral galaxy. This is due to the extensions on the east and west sides which stick out, mimicking spiral arms. It is also fairly even in brightness and contains no central condensation. Using a nebular filter that isolates oxygen emission, strange things happen to M1's shape. The spiral extensions vanish and the nebula dims to about half its former brightness. In addition, the short dimension (north-south) doubles in width and makes the whole object nearly round! This interesting metamorphosis is accompanied by the appearance of a single filament, or wisp, on its southern edge.

These descriptions only scratch the surface of a rich collection of celestial objects — for a more complete listing see the table above. Part two of this article, dealing with the Scorpius/Sagittarius nebulae, will appear in the Summer 1985 issue (*Deep Sky #11*).

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DSM Reports

On Visual Magnitudes

By John E. Bortle

The recent controversy surrounding true integrated "visual" magnitudes for extended deep-sky objects has surfaced time and again in the pages of this magazine and elsewhere. Generally, photographic magnitudes depict objects as being much fainter than they appear to the human eye. Obviously, then, many published magnitudes, obtained by photography in essentially blue light, provide discordant results since the response of the dark adapted human eye is considerably shifted toward the yellow-green portion of the spectrum.

This is especially a problem with planetary nebulae. In the past, many observers were discouraged from looking for various planetary nebulae because they were "beyond the reach of their instruments." A good example of this is the case of Messier 97, the Owl Nebula, in Ursa Major. I have a number of catalogues, many of no great vintage, which list this object at 11th or 12th magnitude. Since my earliest days in astronomy, I could always see the Owl in 10 x 50 binoculars, which had a limiting magnitude of about 11 for a point source such as a star. If its total magnitude were 11, an extended object like M97 would be impossible with the 10 x 50s. Seeing it proved that there was something wrong with the published magnitude.

The situation has improved in more recent years. Photoelectric "V" magnitudes became generally available for a host of extended objects within the past decade or so. While photoelectric V does not precisely represent the response of the dark adapted human eye, it usually approximates true visual magnitude much better than photography. Various formulae have been proposed to convert photoelectric V to visual magnitude — both for nebulae and for stars — but none so far with success.

A second drawback to photoelectric V results because the numbers are generated by professional astronomers, who use big telescopes which "see" more of a given object than amateur instruments. In some cases this provides unrealistically bright values for highly extended objects whose outer regions are beyond our grasp. What we backyard observers need is a catalog of visually determined total magnitudes for extended objects.

It appears that, in this century, only a few attempts at such have been made. Perhaps the earliest important effort was the listing prepared by J. Holetschek of Vienna, a famous observer of comets at the turn of the century. However, there are two serious shortcomings to Holetschek's work. First, he appears to have left no record of the methods he used to obtain his magnitudes. Second, and more important, he compiled this work at a time when magnitude systems were still not precisely fixed. Without filtering them through a non-linear correction scheme, Holetschek's results are probably less reliable than more modern photographic ones.

Max Beyer of Hamburg Observatory undertook a program similar to Holetschek's about 40 years ago. Beyer used dark skies resulting from World War II air raid blackouts and made observations from downtown Hamburg itself. Beyer's credentials for this effort were impeccable. In a long career he amassed upward of 150,000 variable star estimates, and was the world's leading visual observer of comets for nearly half a century. On many occasions he published not only his results but clearly described the methods used to derive them. Before the war put an end to his program, he had made magnitude values for 45 objects, many based on multiple determinations. Beyer routinely published his comet and variable star estimates in the pages of the German publication *Astronomische Nachrichten*, but I have never found anything in it regarding his magnitude determinations of extended objects.

My own involvement in this area began about 1970 when I corresponded with Dr. Beyer concerning photometric observations of comets. At the time we were both very interested in determining if any personal corrections were necessary to link our observations, since our methods differed slightly. Being situated nearly half a world apart, and looking at comets known to change their brightness rather suddenly on occasion, we felt photometric observations of more stable objects would make good tests. Dr. Beyer already had his list of values, so I began compiling my own, initially based on the objects he had observed.

To make the determinations as consistent as possible, I used only a few instruments — 10 x 50 and 20 x 80 binoculars, and in a few instances a 13.7-cm f/5.6 Newtonian reflector at 55x or 110x. I got hold of comparison star magnitudes from the American Association of Variable Star Observers. The AAVSO charts were easily available and provided comparison star fields within a few degrees of most objects. The chart magnitudes, by the way, were made years ago at Harvard Observatory using a visual photometer.

I used two comparison methods in estimating the brightnesses of deep-sky objects. The first method, proposed by Soviet astronomer N.T. Bobrovnikoff in the early 1940s, was the simpler. It consists of defocusing the images of deep-sky objects and the comparison stars until each has a similar diameter. After doing this, select two comparison stars, one fainter and one brighter than the deep-sky object, and estimate the object's brightness in tenths between the two stars. This method is particularly suitable for small, highly condensed objects — I generally used it for the brighter globular clusters and a few galaxies.

With large deep-sky objects, the Bobrovnikoff method gives poor results: the object always remains significantly larger than the out of focus star images, and quickly drops below the sky background threshold when you defocus. (This problem often exists with comets as well.) For diffuse extended objects, you should use a method outlined by J.B. Sidgwick on *Observational Astronomy for Amateurs*. You carefully memorize the size and (in-focus) brightness of the object. Then you defocus the instrument until the out-of-focus star images match the diameter of the memorized in-focus image of the object. Lastly, you compare the defocused star's brightness with the memorized object. To assure accuracy, repeat the procedure several times until you're satisfied. It sounds rather difficult, but after practicing this method you'll become proficient at it.

Comparing the two methods on the same object, I found the Bobrovnikoff method consistently gave results 0.1 magnitudes fainter than those made using the Sidgwick method. Since I had employed Sidgwick's method as my standard through nearly 20 years of photometric observations, I applied a 0.1 magnitude correction to all values obtained using the Bobrovnikoff method. This corrected figure appears in the listings.

Between late 1970 and May 1984, I

made several hundred magnitude determinations of some 65 deep-sky objects using the two methods. In many cases I also recorded the object's apparent size using the same instrument.

Dr. Beyer died early in 1983. Since his data do not appear in the literature, I have taken the liberty of including it here with my own. I know that Beyer used small instruments in determining the magnitudes in the table, although I can find no specifics. He also measured his own comparison star magnitudes with an extinction photometer and considered his values equivalent to those of the International Photovisual System. His method for determining magnitudes of objects was a variation of the Bobrovnikoff method. He defocused the images of the cluster or galaxy and comparison stars and noted their order of disappearance against the sky background. There seems to be a slight systematic trend in Beyer's values toward faintness — nonetheless his figures are listed here as I received them.

The table contains 110 entries representing 91 individual objects observed by Dr. Beyer and myself. The list is composed mainly of the brighter objects of general interest to amateurs. Values for nearly 60% of the Messier objects are provided, and for several emission nebulae total magnitudes are published perhaps for the first time. Nineteen of the objects were mutually observed and, with the exception of one or two entries, these demonstrate the compatibility of the methods, even though the estimates were made many years apart.

The columns in the table provide, respectively, the object's *Revised New General Catalogue* number, Messier number, total visual magnitude, and number of comparisons averaged to obtain the magnitude figure. This is followed by the method employed, the instrument used (if known), and the observer. An "a" following the magnitude value indicates that it is somewhat uncertain or approximate.

Our list covers but a small percentage of the deep-sky objects within range of even small telescopes. Since we are all well aware of how poor the magnitudes are for many fainter objects, perhaps the list may serve as a starting point for some other diligent observers to expand upon.

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Visual Magnitudes for Selected Deep-Sky Objects

NGC	M	Mag.	#	Method	Instrument	Observer
221	32	8.7	4	Bbv	10x50	Btl
221	32	9.0	4	Byr	—	Byr
224	31	4.4	5	Bbv	naked eye	Btl
278	—	10.7	3	Sdg	32-cm	Btl
598	33	5.8	7	Byr	—	Byr
663	—	6.3	5	Byr	—	Byr
663	—	6.8	3	Sdg	10x50	Btl
701	—	11.9	1	Byr	—	Byr
869	—	3.2	3	Bbv	naked eye	Btl
1068	77	9.0	2	Bbv	10x50	Btl
1087	—	10.3	1	Sdg	32-cm	Btl
1907	—	6.3	?	Byr	—	Byr
1912	38	6.0	3	Byr	—	Byr
1952	1	8.7	3	Bbv	10x50	Btl
1960	36	5.8	3	Byr	—	Byr
2068	78	8.3	2	Byr	—	Byr
2099	37	5.6	3	Byr	—	Byr
2158	—	9.3	2	Byr	—	Byr
2168	35	4.6	5	Byr	—	Byr
2281	—	5.9	1	Byr	—	Byr
2287	41	4.5	1	Byr	—	Byr
2323	50	6.1	2	Byr	—	Byr
2360	—	6.8	2	Byr	—	Byr
2438	46	5.6	2	Byr	—	Byr
2632	44	3.3	2	Bbv	naked eye	Btl
2682	67	6.1	1	Byr	—	Byr
2903	—	8.5	2	Sdg	20x80	Btl
3031	81	7.1	3	Bbv	10x50	Btl
3031	81	7.1	4	Byr	—	Byr
3034	82	8.3	4	Byr	—	Byr
3172	—	13.6	1	Sdg	32-cm	Btl
3587	97	9.6	4	Sdg	10x50	Btl
3623	65	9.2	2	Sdg	20x80	Btl
3627	66	8.9	2	Sdg	20x80	Btl
4147	—	9.7	3	Sdg	15-cm	Btl
4214	—	9.9	1	Byr	—	Byr
4374	84	9.2	1	Sdg	20x80	Btl
4406	86	9.2	1	Sdg	20x80	Btl
4486	87	9.1	1	Sdg	20x80	Btl
4552	89	9.6	1	Sdg	20x80	Btl
4569	90	10.1	1	Sdg	20x80	Btl
4579	58	9.7	1	Sdg	20x80	Btl
4631	59	10.1	1	Sdg	20x80	Btl
4649	60	8.9	1	Sdg	20x80	Btl
4736	94	8.4	3	Bbv	10x50	Btl
4736	94	8.5	1	Byr	—	Byr
5024	53	7.9	3	Bbv	10x50	Btl
5055	63	9.1	2	Sdg	20x80	Btl
5194	51	8.1	5	Byr	—	Byr
5194	51	8.3	2	Sdg	20x80	Btl
5272	3	6.2	3	Bbv	10x50	Btl
5272	3	6.3	4	Byr	—	Byr
5457	101	8.0	3	Sdg	10x50	Btl
5668	—	11.5	1	Byr	—	Byr
5866	—	9.9a	2	Byr	—	Byr
6171	107	8.2	4	Sdg	10x50	Btl
6205	13	5.7	3	Bbv	10x50	Btl
6205	13	5.8	9	Byr	—	Byr
6207	—	12.0	1	Sdg	32-cm	Btl
6210	—	9.2	6	Sdg	10x50	Btl
6218	12	7.1	3	Bbv	10x50	Btl
6229	—	9.4	2	Byr	—	Byr

Name code for method and observer: Bbv = Bobrovnikoff, Btl = Bortle, Byr = Beyer, Sdg = Sidgwick. Table continues overleaf:

Visual Magnitudes for Selected Deep-Sky Objects

NGC	M	Mag.	#	Method	Instrument	Observer
6254	10	6.8	3	Bbv	10x50	Btl
6333	9	7.9	2	Bbv	10x50	Btl
6341	92	6.2	3	Bbv	10x50	Btl
6341	92	6.7	6	Byr	—	Byr
6402	14	7.9	2	Sdg	10x50	Btl
6475	7	2.7	3	Bbv	naked eye	Btl
6523	8	3.6	2	Bbv	naked eye	Btl
6543	—	8.3	1	Sdg	10x50	Btl
6543	—	8.3	3	Sdg	10x50	Btl
6626	28	7.3	1	Bbv	10x50	Btl
6656	22	5.7	4	Bbv	10x50	Btl
6694	26	7.3	4	Byr	—	Byr
6694	26	7.9	1	Bbv	10x50	Btl
6705	11	5.8	1	Bbv	10x50	Btl
6705	11	5.9	5	Byr	—	Byr
6712	—	8.3	6	Byr	—	Byr
6712	—	8.7a	2	Sdg	10x50	Btl
6715	54	7.9	3	Sdg	10x50	Btl
6720	57	8.6	1	Bbv	10x50	Btl
6760	—	8.9	4	Byr	—	Byr
6779	56	8.3	4	Byr	—	Byr
6779	56	8.5	4	Bbv	10x50	Btl
6809	55	6.2	3	Sdg	10x50	Btl
6811	—	7.7	2	Byr	—	Byr
6819	—	7.7	1	Byr	—	Byr
6838	71	7.9	1	Bbv	10x50	Btl
6853	27	6.9	7	Byr	—	Byr
6853	27	7.1	1	Bbv	10x50	Btl
6934	—	8.8	4	Byr	—	Byr
6939	—	8.4	1	Sdg	20x80	Btl
6946	—	9.2	1	Sdg	20x80	Btl
6981	72	9.3	6	Byr	—	Byr
6994	73	9.0	6	Byr	—	Byr
7006	—	10.3	3	Byr	—	Byr
7006	—	10.4	3	Sdg	15-cm	Btl
7009	—	7.8	1	Bbv	10x50	Btl
7009	—	7.8	4	Byr	—	Byr
7078	15	6.6	3	Bbv	10x50	Btl
7078	15	6.7	5	Byr	—	Byr
7089	2	6.4	4	Bbv	10x50	Btl
7089	2	6.7	9	Byr	—	Byr
7293	—	7.2	1	Bbv	10x50	Btl
7331	—	9.9a	3	Byr	—	Byr
7510	—	8.2	3	Sdg	10x50	Btl
7662	—	8.5	3	Sdg	10x50	Btl
7789	—	6.2a	3	Byr	—	Byr
7789	—	6.6	3	Sdg	10x50	Btl
Pleiades	45	1.2	3	Bbv	naked eye	Btl

Name code for method and observer: Bbv = Bobrovnikoff, Btl = Bortle, Byr = Beyer, Sdg = Sidgwick.

Ross 15 and Plate FS-48

By Paul Roques

Finding something you're not looking for, especially while you're actively looking for something else, constitutes serendipity. As backyard observers, we're aware of exciting things that can happen in the sky: a nova or supernova eruption, strange behavior from a variable star, a previously unseen comet showing up, and so on. Over two decades ago, while I worked at Los Angeles' Griffith Observatory, I made such a serendipitous observation — one which remains unresolved today.

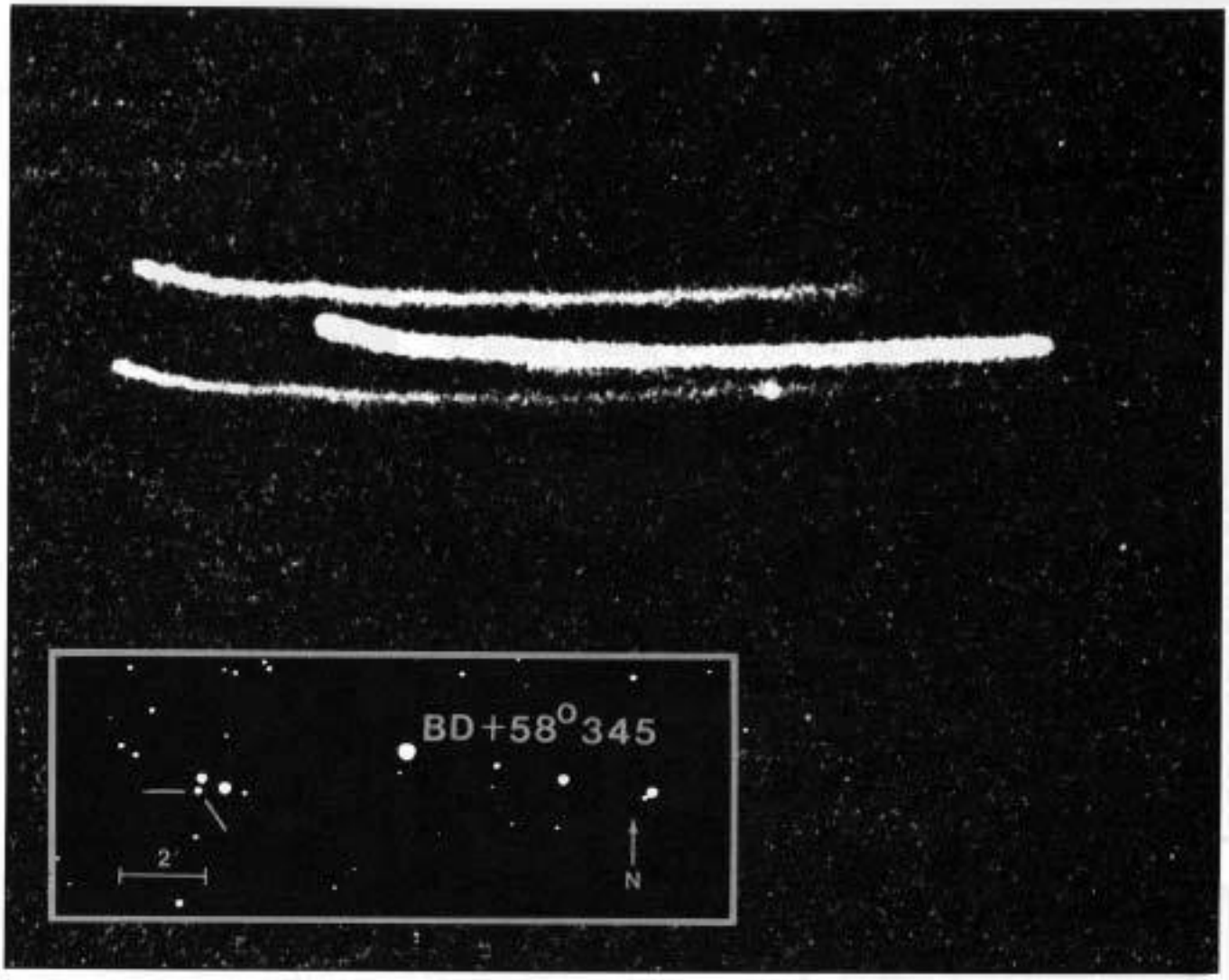
It started early in 1952, when photoelectric monitoring of UV Ceti stars (flare stars) began at the observatory. (This method is now widely used at most observatories as a means of checking the behavior of these erratic stars.) As Griffith's program evolved, we added photographic methods as a step toward using our observing time more effectively.

We photographed red dwarf stars showing strong H and K emission lines and hyrdogen in their spectra (this indicated they had active chromospheres) in order to select the best candidates for photoelectric surveillance. If we detected a brief flare, we transferred the red dwarf to the photoelectric list in the hopes of recording light curves of a flare event. The photographic phase of the program operated very simply. We adjusted the telescope's drive rate to produce a drift trail for the star that put the stellar image on the photo one to two magnitudes above the detection threshold — i.e., sky fog. (Had we tracked at the sidereal rate, there would have been no trail and the flare would be lost in the round stellar images. Had we trailed the star with no tracking at all, we couldn't have photographed stars as faint as we needed to.) Tracking at the right rate, we found that a rapid brightening of a few tenths of a magnitude could be readily discerned during periods of good seeing as a "blip" on the star trail.

Whereas the photoelectric work forced observers to stay at the telescope to keep the aperture diaphragm centered on the star and to make periodic measurements of sky brightness, the photographic procedure required almost no attention other than changing plates and resetting the telescope at the end of each drift interval. This was especially useful, since relatively inexperienced observers could participate in the program — without having to combat the temperamental behavior of dry ice cooled photometers of 30 years ago.

In addition to inspecting drift trails of each candidate star, the entire plate was routinely scanned as a final step. Other than an occasional meteor trail, the sweep of each plate revealed nothing, with one exception — good old plate FS-48. Drift plate FS-48 was exposed on October 9, 1961 for the potential flare star Ross 15 in Cassiopeia. When scanned, the plate showed no variability in Ross 15, but instead exhibited what appeared to be a substantial flare in an 11th magnitude field star. Was this a coincidentally-placed flaw in the emulsion? Critical examination under high magnification revealed a well-centered image on the drift trail, and a density profile uncharacteristic of a flaw — a combination of factors that made a random artifact of the emulsion highly improbable.

Astronomers who critically examined the image judged it to be real and the result of a brief and rapid brightening of about one magnitude. This was surprising, but the results of a low-dispersion spectrogram, obtained two years later by Joseph Miller with Lick Observatory's 36-inch Crossley reflector, were totally unexpected. The



star was classified as K3 V (a yellowish main sequence dwarf), with no apparent emission lines — certainly not the profile of a typical UV Ceti star. (The position of BD+58°345 is α = 1h59m51s, δ = 59°09′37″, 2000.0 epoch.)

Was this event actually an enormous flare capable of briefly increasing the visual brightness of a K3 star by a full magnitude? Or is there a dimmer companion star nearby that flared with enough energy to increase the *combined brightness* of the system by a full magnitude? Since this was the single plate of 16 showing flare activity, we searched through other photographic records for evidence of past flare-ups of the star.

On the remote possibility that Harvard College Observatory might have recorded earlier outbursts, we asked Margaret Mayall, then director of the American Association of Variable Star Observers, to examine the 140 Harvard Observatory patrol plates of the region. These were taken at a rate of four or five per night between September 1945 and January 1946. The results of her search were negative, but as she noted, the camera's small plate scale may have caused the image of a companion to blend in with a brighter star to the north, reducing the probability of detecting a flare. At Griffith Observatory and elsewhere, we continued photographic monitoring of the star for the next 6 years, accumulating a total of 97 hours of recording with no positive results. With observing time being expensive, we finally had to drop the K3 star from the program in favor of increased photoelectric coverage of the more "conventional" flare stars.

The past 23 years have given rise to the development of vastly improved photographic materials and the continual introduction of sophisticated, readily-available instruments. As a result of these advances, amateur astronomers may now be in a position to confirm this star's intermittent activity. Whereas our initial surveillance barely covered 0.2 percent of the 6-year observational interval, active amateur astronomers could effectively enlarge that coverage by an overwhelming factor. Although a photoelectric photometer and chart recorder can yield detailed information when a flare occurs, the simple drift method — the one used in the initial discovery — is a useful way to gether data quickly.

Successfully extracting plate information begins with realizing that any periodic tracking error in the telescope's drive system will introduce irregularities in the drift images. These distortions are readily apparent since their regular pattern shows up on all trails of a given negative. Should anything unusual appear on the target star, you can check by comparing it to other stars on the photograph.

Practicing these surveillance techniques — or a high-resolution spectroscopic study with a large telescope — offer a promising direction for a renewed investigation of this enigmatic K3 star.

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For many years Paul Roques was an astronomical observer at Griffith Observatory in Los Angeles. He now works with Allan Sandage of Mount Wilson and Las Campanas Observatories, conducting photometry of globular clusters.

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Double Stars

The Double Stars of Gemini, the Twins

by Glenn F. Chaple, Jr.

It seems only proper that a constellation nicknamed the Twins should fairly teem with double stars! Its alpha star, **Castor**, is one of the finest doubles in the heavens. Castor's duplicity was discovered in 1718 by the English astronomers James Bradley and John Pound, although evidence indicates that it may have been resolved by Cassini 40 years earlier. Studies of Castor's components led William Herschel to announce, in 1803, that they were gravitationally bound, rather than being aligned by mere chance. Castor, therefore, became the first double star to be recognized as a true binary system.

During this century, Castor lost its appeal as a target for amateur-size telescopes. Some 5.5 arcseconds apart in 1900, the components — of magnitudes 2.0 and 2.9 — began closing together until by 1965, they were just 1.8″ apart. They are once again separating and are currently a bit over 2.5″ apart. This distance will increase to 3.4″ in another decade and a comfortable 4.0″ by the end of this century. As it becomes more readily visible through small telescopes, Castor will once again enjoy great popularity with amateur skywatchers. Many will be so dazzled by the brilliance and beauty of this pair that they won't notice a 9.5 magnitude star just 73″ away.

Suppose we could cross the 45 light-years that separate us from Castor. From our vantage point, we would make a fabulous discovery. Each of Castor's bright components is itself a binary system. Castor A consists of a matched pair of A-type stars that complete an orbit in a little over 9 days. Castor B is also a twin system, again pairing stars of spectral class A. Its components, which like those of Castor A, are slightly larger than our Sun, complete an orbit in about 3 days. In addition, Castor A and B orbit each other in a period equal to seven human lifetimes.

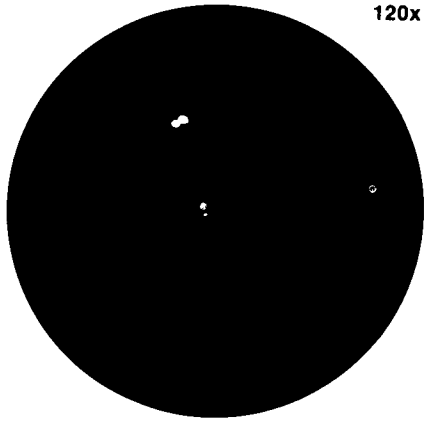
But let's not forget that 9.5 magnitude neighbor. Incredibly enough, it is also a twin system. This time, however, each component is a red dwarf slightly smaller than our Sun. They are extremely close and complete an orbit in less than a day. Located one hundred billion miles from Castor A and B, Castor C circles both pairs once every 10,000 years. What a shame that the components of each pair are so close as to appear single in earthbound telescopes!

Four of Gemini's Greek-letter stars are wide unequal pairs that may be readily viewed with small telescopes. They are ε (magnitudes 3.0 and 9.2; separation 110.3″; position angle 94°; 1925), ζ (variable 3.6-4.2 and 8.0; 96.5″; 350°; 1925), μ (2.9 and 9.5; 121.7″; 141°; 1899), and ν (4.1 and 8.6; 112.5″; 329°; 1924). All these pairs appear to be optical, rather than physical. **Epsilon** took center stage on the night of April 7, 1976, when it was occulted by Mars. Clear New England skies afforded me a ringside seat to this rare celestial spectacular.

Zeta is a Cepheid variable with a period of just over 10 days. It has a second, rather feeble optical partner that shines at magnitude 10.5. You'll find this star 87″ east of the primary. **Mu** and **Nu** lie at the foot of one of the Twins and are only a few degrees apart. The former sports an M-type primary that T. W. Webb called "crocus yellow." Its companion is an extremely close pair, perhaps beyond the resolving limit of most amateur-owned scopes. My favorite of these four wide pairs is Nu, because it is joined by another double — 15 Geminorum (7.0 and 9.0; 27.1″; 204°; 1957) — in the same low-power field.

The toughest double stars to resolve are the close unequal ones. Invariably, the lesser star is lost in the glare of the primary or hides in one of the main star's diffraction rings. One double star that I've never split with my 3-inch reflector, despite numerous attempts, is δ Geminorum (3.2 and 8.2; 6.3″; 218°; 1962). This is especially frustrating, since *Norton's Star Atlas* describes it as a test for a 2-inch scope! Aarrghh! Those of you with 2- or 3-inch telescopes, particularly refractors, are urged to try this pair.

Castor — **3-inch f/10 reflector 120x**



Sketch by Glenn F. Chaple, Jr.

Castor — **12-inch f/30 Ritchey-Chretien TP 2415 2 seconds**

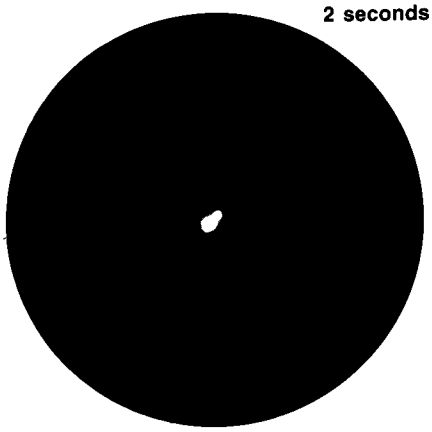


Photo by John Sanford

Before bidding farewell to Gemini, let's pause to view two of its prettiest doubles. The first of these is **20 Geminorum** (6.7 and 6.9; 20.0″; 210°; 1956), which is situated roughly midway between ν and γ Geminorum. The component stars of this striking duo

Star	R.A. (2000)	Dec.	Mags	Sep	PA	Year
Mu (μ)	6h 22.9m	22° 31′	2.9, 9.5	121.7″	141°	1899
15	6h 27.7m	20° 48′	7.0, 9.0	27.1″	204°	1957
Nu (ν)	6h 28.9m	20° 14′	4.1, 8.6	112.5″	329°	1924
20	6h 32.4m	17° 47′	6.7, 6.9	20.0″	210°	1956
Epsilon (ε)	6h 43.6m	25° 06′	3.0, 9.2	110.3″	94°	1925
38	6h 54.6m	13° 10′	4.8, 7.5	7.0″	151°	1962
Zeta (ζ)	7h 04.0m	20° 34′	3.6-4.2, 8.0	96.5″	350°	1925
Delta (δ)	7h 20.2m	21° 59°	3.2, 8.2	6.3″	218°	1962
Alpha (α)	7h 34.6m	31° 53°	2.0, 2.9	2.6″	85°	1985
			9.5	72.5″	164°	1955

Epsilon Geminorum and Mars, 1976

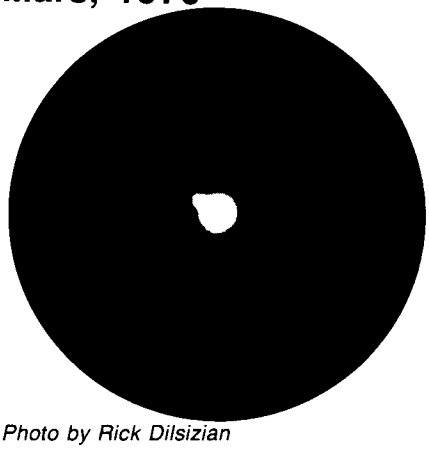


Photo by Rick Dilsizian

share a common proper motion and thus are believed to be physically bound. To find our second "Gemini Special," look about 3° west of ξ Geminorum. The exquisite little pair that dwells there is **38 Geminorum** (4.8 and 7.5; 7.0; 151°; 1962). These stars form a slow-moving binary with a period of some 30 centuries. Webb called them yellowish and bluish, colors I failed to notice when I viewed 38 Gem with my 3-inch reflector. Nevertheless, the pair was a beautiful sight at 60X.

DOUBLE TAKES: Gus Johnson of Swanton, Maryland sent the following notes on some of the Libra doubles featured here last summer:

Iota B	Seems elongated with averted vision using a 3-inch f/16 Unitron and 171x.
Hh 457	Gold-blue (maybe due to contrast). 6-inch f/8 reflector at 49x.
Hh 467	Seen low in hazy sky with 8-inch f/5.7 reflector at 58x. White? Easy, unequal pair.

Steve Coe, an amateur in Phoenix, Arizona, forwarded a page of notes describing some of his favorite double and multiple stars. Some of Steve's entries are currently visible in the evening sky. Try your luck with:

Eta (η) Cas	Easy split in 8-inch f/6 Newtonian, pale yellow and orange.
Eta (η) Per	Wide pair, golden and royal blue.
Iota (ι) Cnc	Wide pair, gold and light blue.
Beta (β) Mon	Three 5th magnitude stars form a flattened triangle. Split at 100x in 8″, all 3 white. What do astronomers do in a system with three suns? *[Probably play a lot of Trivial Pursuit! — GFC]*
Σ644	In Auriga. Split at 150x in 8 inch, yellow and light blue.

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Variable Stars

Out of Tune

by David H. Levy

The Angels all were singing out of tune
And hoarse with having little else to do
Excepting to wind up the Sun and Moon,
Or curb a runaway young star or two.

George Gordon, Lord Byron, ca. 1800

Our variable star choir is out of tune. This season we'll look at a number of stars that represent many of the types of variables that you can find in the winter sky. Some have known periods while others do not, but they all share a measure of "runaway" behavior, an uncertainty that makes them a challenge and joy to observe.

In winter we reflect, drawing ourselves inward a bit as the cold weather and short days beckon us away from the stars and toward the armchair. But the nights are so much longer, and the unparalleled richness of the winter sky is always there, daring us to shun indoor comforts and go outside and watch.

Was Byron a variable star observer, observing the young stars in the Orion Nebula around 1800? Hardly. But let's begin with Orion, whose Great Nebula is worshipped by all deep-sky observers and contains some of the most interesting variables of the entire sky. These are all young stars, only a few million — possibly a few hundred thousand — years old. Lurking within the nebula are some 50 variable stars, 10 of them bright enough to be observed with a 6-inch telescope.

These nebular variables are not, I caution you, traditional stars with long well-established periods. They are young stars that flicker by a half magnitude or so over a period of a few minutes. Because they are embedded in the uneven background of the Orion Nebula, they are very hard to estimate. Try looking every 10 or 15 minutes; take care not to be fooled by the cacophony of other stars in the nebula which may also be varying. For each variable, always use the same comparison stars and estimate only on nights when no cirrus clouds interfere with sky transparency. The AAVSO does not encourage any but the most experienced observers to attempt these stars, so if you decide to try, be careful!

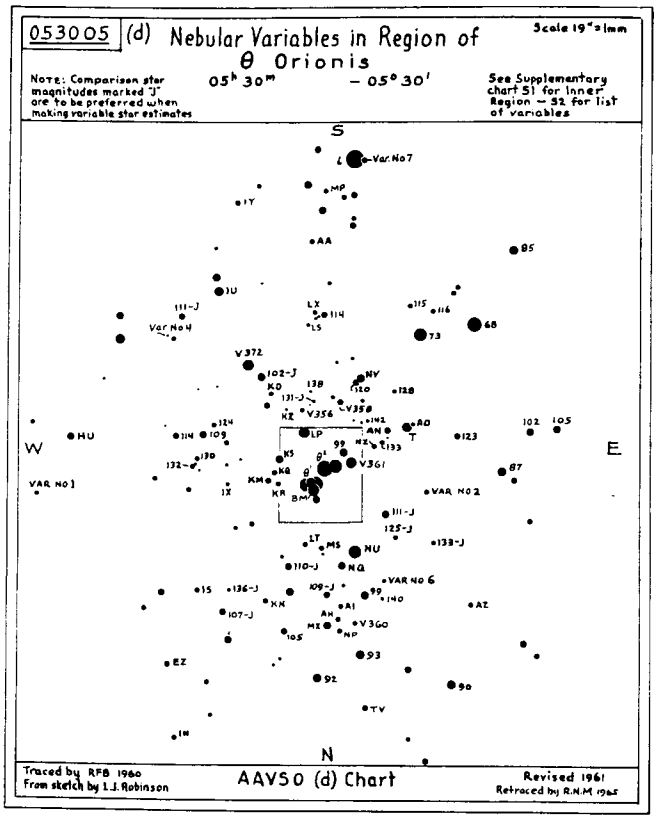
One of the M42 stars is an exception — *053005* **T Orionis**, a nebular variable with a significant amplitude and variation that follows a detectable pattern over a long term. Although T Ori has small, quarter-magnitude variations that resemble those of its neighbors, it also offers a completely irregular pattern of sudden drops of several magnitudes that resemble those of the "reverse nova" R Coronae Borealis.

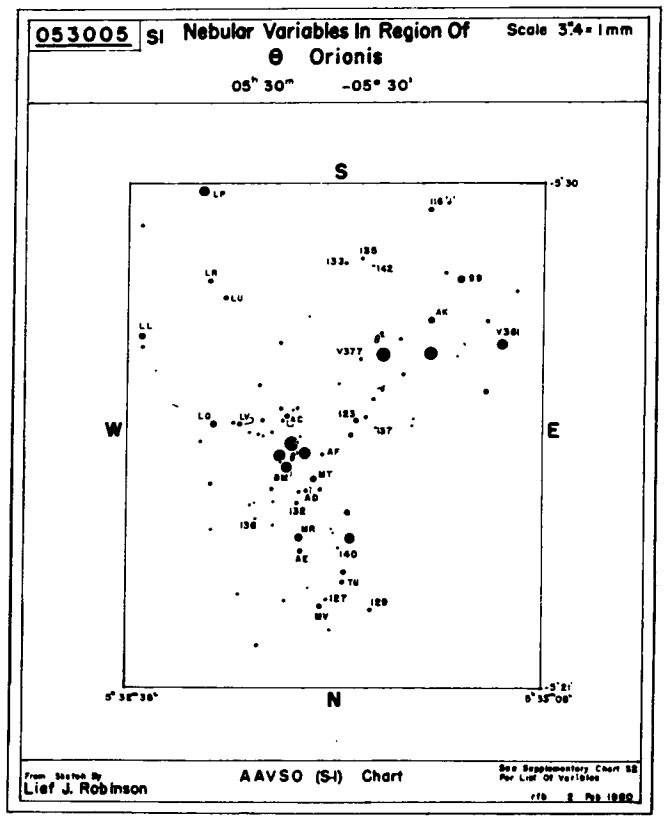
If you limit your nebular watching to T Ori, you can check it every 15 minutes for possible (but difficult-to-detect) small variations, or you can observe it once a night for signs of a plunge from its normal maximum magnitude of 10.2 — it has been seen occasionally at 9.5 — to a minimum at 12.6. Of course, if the star is already at minimum when you begin, you'll need a large telescope just to spot it.

While visiting Orion, take a look at 054907 **Betelgeuse** (Alpha [α] Orionis) — one of the brightest stars in the sky and most definitely a variable worth watching. In a somewhat stretched sense, Betelgeuse is a supernova candidate: at a mere 100 light-years' distance, it might give the uninitiated something to worry about. But being a supernova candidate and actually *going* supernova are two different things; it may be millions of years before Betelgeuse does anything. For our interests right now, tonight in fact, Betelgeuse is doing something else that's interesting — it is acting as a semiregularly fluctuating red supergiant with an "official" period of 2070 days. That period is theoretical, since you can observe this star changing from its maximum of magnitude 0.3 down to 0.7 within a week or two — thus the star is a worthwhile observational target. Estimate twice a month and use stars that do not differ too much in altitude from the variable, since atmospheric extinction will introduce a false difference in magnitude. Also, since Betelgeuse is a red star, use quick glances rather than prolonged stares to avoid red buildup (the "Purkinje effect") in your eye.

Another bright red giant that varies irregularly and is worth a look is 060822 **Eta (η) Geminorum**, not far from the open cluster M35 in Gemini. This star varies from magnitude 3.3 to 3.9 in a mysterious fashion about which little is understood, but the star is easily found and estimated with unaided eye or binoculars.

Let's now look at a variable of a different type: 074922 **U Geminorum**, a dwarf nova like SS Cygni. This star, normally a faint magnitude 14.2, can increase in brightness to 8.8 in just a few hours. Although there are a number





The region in and around the Orion Nebula is especially rich in variables, most of them the "nebular" kind. A nebular variable — of which there are several distinct subclasses — is a very young star that is in the process of evolving onto the main sequence. Characteristically, they have small rapid fluctuations in brightness and are tricky, but rewarding, to observe. Charts courtesy of Janet A. Mattei, AAVSO.

of dwarf novae spread throughout the sky, by far the best known are U Geminorum in the winter and SS Cygni in the summer. This star deserves watching every night — or every hour if you catch it going into outburst.

We've looked at Gemini for a cornucopia of different variables this season; now let's explore a more traditional Mira-type star, a slow and leisurely long period variable. 070122 **R Geminorum**, the first variable to be discovered in Gemini, has a maximum at 6.0 and a minimum of 14.0. It normally fades and brightens again in a little over a year, 370 days. Like most long-period variables, the beauty of this star lies in its vague predictability. The predictions can tell you that it will reach maximum about a certain date, and reach minimum some months later. But the real courses of these stars are not as well understood as they might be, even though astronomers have been watching them for decades. The stars vary arrhythmically enough so that each light curve is slightly different, both in type and in style. What causes this slight irregularity? Perhaps with more high-quality light curves, we may soon have the data for an answer. R Gem also varies somewhat in its spectral type, from S3 to S6.

Let's end with another strange irregular star, also bright, this one in Cassiopeia. **Gamma (γ) Cassiopeiae** (005060) normally shines at about magnitude 2.5. But in 1936, Leslie Peltier watched it slowly rise until it rivaled magnitude 1.6 Deneb. In 1965 Gamma showed signs of fluctuating irregularly again, but this time it did not show such a striking increase. Since then, it has sat almost unchanged at approximately magnitude 2.5. You never know when this unique star will rise again. It's easy to find and it offers historical importance, so why not observe it once a month — just in case?

How often should you estimate a variable star? I advise intervals ranging from a few minutes to 30, depending on the nature of the variable. A good observer's work will reflect the variable's pattern of behavior. Some observers like to estimate the slow and stately Mira stars, with their nine-month periods, each night; but such frequency is redundant and adds little to your understanding of the star's behavior. On the other hand, if you observe U Gem only twice a month, you're liable to miss a rise and fall from maximum completely! When you get a bit more experience with variable star observing and the stars you follow, you will develop a sense of how often you should observe the different members of our variable choir.

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Designation	Name	Range	Period	Type
053005	T Orionis	9.5-12.6	Irregular	nebular
054907	Betelgeuse (Alpha [α] Orionis)	0.4-1.3	2070 days?	semi-regular
060822	Eta Geminorum	3.3-3.9	233 days	semi-regular
005060	Gamma Cassiopeiae	1.6-3.0	Irregular	nova-like
074922	U Geminorum	8.8-14.2	102 days	dwarf nova
071022	R Geminorum	6.0-14.0	370 days	Mira-type

Scanning the Literature

July — September 1984

by Brian Skiff

The Mount Wilson astronomer Halton "Chip" Arp continues to make unconventional studies of possible associations between high-redshift quasars and nearby galaxies. His latest contribution involves the brightest galaxy in a cluster frequently observed by amateurs ("Two Newly Discovered Quasars Closely Spaced Across a Galaxy," *Astrophysical Journal*, **283**:59, August 1). A matched pair of X-ray sources near NGC 3842, at the center of the rich galaxy cluster Abell 1367, are shown to correspond with quasars. The two 17th magnitude objects have very different redshifts — despite being identical in brightness — and both have much larger redshifts than the nearby galaxy. Arp suggests other X-ray sources in the region of the cluster should also be checked out for quasars.

An exceptional study of faint galaxies in the Virgo cluster is presented by Allan Sandage and Bruno Binggeli in the July *Astronomical Journal* ("Studies of the Virgo Cluster. III. A Classification System and an Illustrated Atlas of Virgo Cluster Dwarf Galaxies," *AJ* **89**:919). The study is based on a large number of plates taken with the DuPont 2.5-meter telescope at Las Campanas, Chile, whose optics are specially designed to cover a wide field.

As a start in studying the Virgo dwarfs, Sandage and Binggeli devised a classification scheme that parallels the familiar Hubble types but at a low luminosity level. Dwarf galaxies of most classes form a continuum in total brightness: for instance, there are ellipticals at all magnitudes from the supergiant Messier 87 to those at the limit of the survey (around absolute B magnitude −14). An interesting feature of some of the dwarf ellipticals and lenticulars (S0's) is the presence of a bright starlike nucleus within a low-surface-brightness halo. Dwarf ellipticals and irregulars dominate the list, but the astronomers found "no equivalent in the spirals of the Hubble sequence at faint absolute magnitudes." This is consistent with existing theoretical models of galaxy formation, where there is *some* lower limit to the mass necessary to form spiral arms.

Several "blue compact dwarfs" were also catalogued in the survey. These are galaxies apparently consisting only of a few bright knots: they resemble giant H II regions like the Tarantula Nebula in the Large Magellanic Cloud, and are embedded in an envelope of low surface brightness gas. A plausible interpretation of these objects is that they are the same sort of beast as dwarf irregulars, but are presently undergoing intense bursts of star formation.

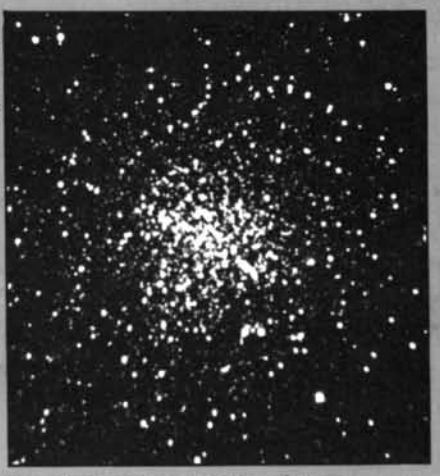
Sangage and Binggelli apparently discovered a new class of galaxies during the search — dwarf ellipticals and irregulars of large size and extremely low central surface brightness (only about 25 blue magnitudes per square arcsecond). No objects like this are known in the Local Group, and it's not hard to see why: at the distance of the Andromeda Galaxy they would cover 3° to 4° and would shine at only one-tenth the surface brightness of the nighttime sky.

The paper contains a collection of first-class photos of 138 galaxies (many are NGC/IC objects), as well as accurate positions, types and integrated magnitudes.

Jack Newton

Virgo: ***Clues to galaxy formation***

Jack Marling



M4: ***The closest globular cluster***

The first photometric study of a distant dwarf irregular in the Local Group has been made by Serge Demers and collaborators ("Leo A: Color-Magnitude Diagram of Its Brightest Stars," *AJ* **89**:1160, August). The group took plates with the 3.6-meter Canada/France/Hawaii telescope on Mauna Kea, established a photoelectric sequence to calibrate them with the 1.6-meter Mont Megantic telescope in Quebec, and digitally scanned the plates at England's Cambridge Institute of Astronomy. (How's that for traveling!) The galaxy's brightest stars are blue supergiants shining at about V magnitude 19.5. The distance is estimated to be 2.3 megaparsecs, giving the galaxy an absolute magnitude of only −14.4. The photoelectric sequence of stars (between V magnitude 13 and 19) around the object is identified in large-scale photos, which also show the galaxy to be well-resolved and sparsely-populated.

Another nearby galaxy gets some overdue attention in John A. Graham's study "The Cepheid Variables in NGC 300" (*AJ* **89**:1332, September). Graham blinked 4-meter CTIO prime-focus plates for variables in NGC 300. The traditional distance indicators, Cepheids, comprised most of the variables. Showing up at only V magnitude 20 and fainter, they imply a distance of 1.65 megaparsecs, confirming that NGC 300 is one of the closest galaxies outside the Local Group.

One explanation for the "missing mass" in individual galaxies and in galaxy clusters is that it is provided by very-low-mass stars — or "warm planets" like Jupiter — unable to shine by nuclear fusion as in normally luminous stars. Up to now these objects, if they exist, have not been detected at any wavelength. H. Karimabadi and Leo Blitz show this may not be possible with current technology in "The Detectability of Population III "Jupiter's," (*Astrophysical Journal* **283**:169, August 1). They calculated the total contribution to the electromagnetic background by enough of these objects to make up the "missing mass" detected in various cosmological studies. The exceedingly weak energy from such cool objects radiates mostly in the far infrared between 10 and 100 microns. In the best case, the authors found the energy per unit area of sky from a universe full of these "Jupiters" is only one-tenth that detectable by the

most sensitive instruments available. Oh well.

A more successful study of our galactic halo is presented in "A Search for Distant Halo RR Lyrae Stars," by A. Saha (*ApJ* **283**:580, August 15). The author used long exposure Palomar 1.2-meter Schmidt plates to find variables as faint as B magnitude 19.5, corresponding to a distance for RR Lyraes of over 40 kiloparsecs from the galactic center. He then used a photoelectric vidicon camera on the Palomar 1.5-meter scope to obtain light curves for three dozen of the stars. Finding such stars so far from the disk of our Galaxy provides valuable information about the overall structure of the Milky Way.

Discussion of other RR Lyrae stars dominates a survey by Amelia Whelau and Helen Sawyer Hogg ("Variable Stars in the Globular Cluster Messier 28," *AJ* **89**:1005, July). The two astronomers found twenty-four variables, and were able to derive light curves for nineteen of them from available photographs. An RV Tauri-type star in the cluster peaks at B magnitude 13, but the more common RR Lyraes have a mean B magnitude of 16.0.

A tour-de-force photometric study of Messier 4 has been produced by Gonzalo Alcaino and William Liller ("BVRI Main-Sequence Photometry of the Globular Cluster M4," *ApJ Supplements* **56**:19, September). B and V magnitudes are given for 1400 stars (plus R and I for nearly 200 of these) to V magnitude 19. The paper includes a great collection of photographic finder charts of cluster stars (even a big "centerfold"), including one of short exposure showing individual stars in the "star-bar" often observed visually across the core of the cluster. The authors confirm that — at 2 kiloparsecs — M4 is the closest globular to Earth. The cluster is dimmed almost 1½ magnitudes by intervening dust associated with the expansive Rho (ϱ) Ophiuchi cloud.

Milky Way observers can check their limiting magnitudes in the field around the globular NGC 6522 in Sagittarius with stars measured by V.M. and B.M. Blanco ("A B,V Sequence in Baade's Window," *P.A.S.P.* **96**:603, August). The cluster sits in a small area of relatively low interstellar obscuration which permits observation of stars near the nucleus of the Galaxy. Here Walter Baade studied RR Lyrae variables (there they are again!) extensively just after World War II, so that his name has become attached to the region.

The Blancos used traditional photoelectric measures, photographs scanned on a microdensitometer, and CCD frames to establish the magnitudes and colors of 70 stars between V magnitudes 11 and 19. There appear to be no systematic errors in the magnitudes, but the dense star background produces an uncertainty of up to one-quarter magnitude at the faint end. Since this background is dominated by the light of distant red giant stars, the authors note that the color of the "sky" in this area is B–V=1.2 — much redder than that found away from the Milky Way, which is dominated by sunlight scattered by the zodiacal light. A photograph showing just how dense the star background is identifies the measured stars, which include a number of M giant variables.

NGC 300: ***20th magnitude Cepheids establish a distance of 1.65 Mpc.***

New results about nearby stars similar to the Sun (see *Deep Sky* #8, page 38) are given in a pair of papers in the September *P.A.S.P.* The first ("Chromospheric Emission and Rotation of the Hyades Lower Main Sequence," *P.A.S.P.* **96**:707), by a Harvard-Mount Wilson group led by Doug Duncan, gives observations of calcium H and K emission for stars in the Hyades. The average levels of stellar activity vary smoothly with spectral type, increasing for the cooler stars of later spectral type. The data do not clearly show evidence of rotation, but this *is* seen in data presented in the companion paper by "a cast of thousands" based at Lowell Observatory under Wes Lockwood ("The Photometric Variability of Solar-Type Stars. IV. Detection of Rotational Modulation Among Hyades Stars," *P.A.S.P.* **96**:714). High-precision photoelectric observations were made of many of the same stars observed at Mount Wilson. About half the stars are variable (with a typical range of just 0.03 mag.), all of which are cooler than spectral type F7 V. Nine of the variables are periodic, and the variation in a few cases is correlated with the calcium emission variations observed during the same time interval at Mount Wilson.

Finally, in the "fundamental data sources" department, we have "Close Visual Binaries. I. MK Classifications," by Christopher J. Corbally, S.J. (*ApJ Supplements* **55**:657, May). Spectral types are given for both components of 170 close pairs (typically 1″ to 5″ separation), nearly all of which are in the southern hemisphere. These will be of interest to observers since the expected apparent colors of the stars can be estimated without bias.

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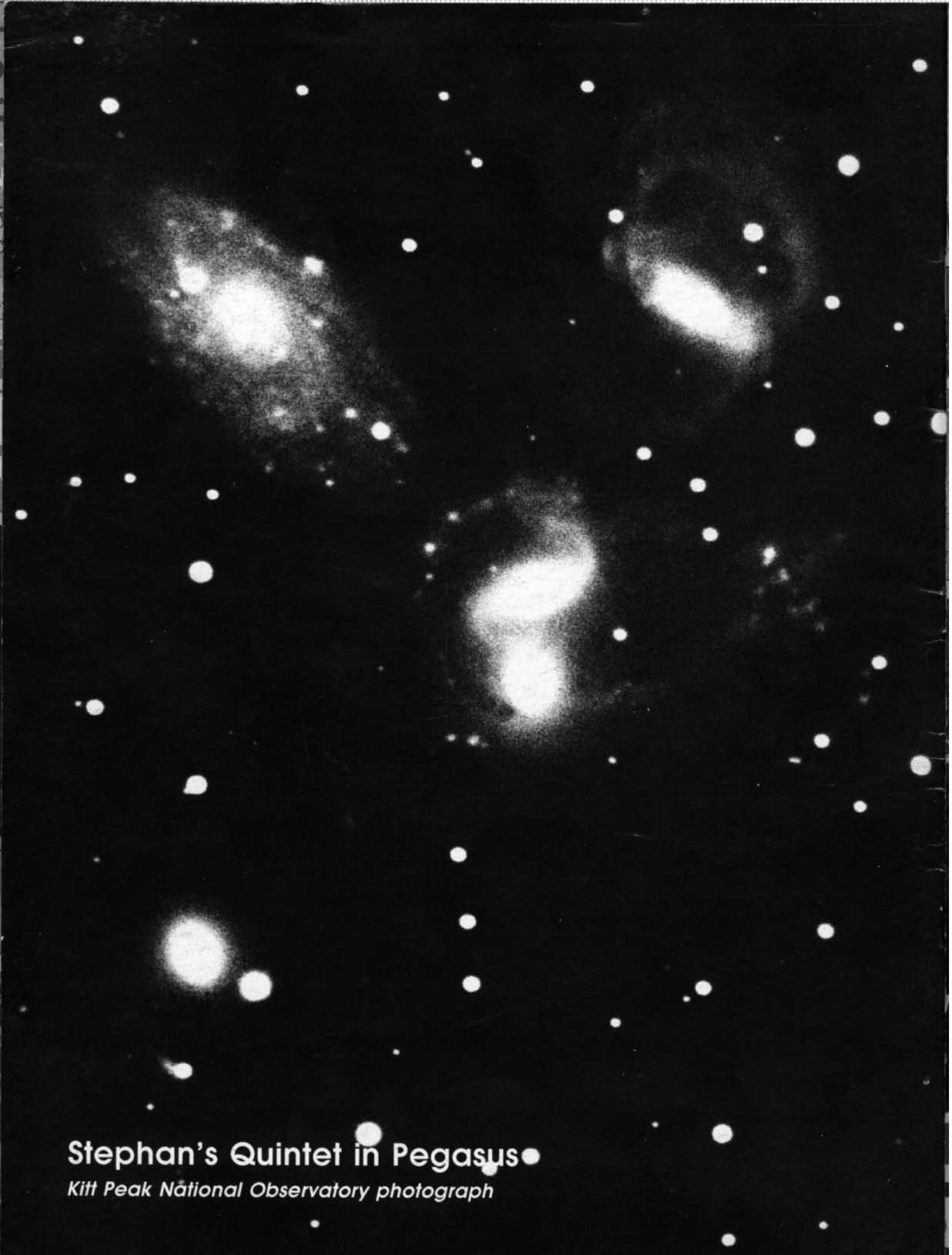

Stephan's Quintet in Pegasus

Kitt Peak National Observatory photograph